# FLIGHT
and The AIRCRAFT ENGINEER

FIRST AERONAUTICAL WEEKLY IN THE WORLD : FOUNDED 1909

Editor
C. M. POULSEN

Managing Editor
G. GEOFFREY SMITH

Chief Photographer
JOHN YOXALL

Editorial, Advertising and Publishing Offices: DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1

Telegrams: Truditur, Sedist, London. Telephone: Waterloo 3333 (50 lines).

8-10, CORPORATION ST., COVENTRY. *Telegrams:* Autocar, Coventry. *Telephone:* Coventry 5210.

GUILDHALL BUILDINGS, NAVIGATION ST., BIRMINGHAM, 2. *Telegrams:* Autopress, Birmingham. *Telephone:* Midland 2971 (5 lines).

260, DEANSGATE, MANCHESTER, 3. *Telegrams:* Iliffe, Manchester. *Telephone:* Blackfriars 4412.

26B, RENFIELD ST., GLASGOW, C.2. *Telegrams:* Iliffe, Glasgow. *Telephone:* Central 4857.

SUBSCRIPTION RATES: Home and Canada: Year, £2 6 0. 6 months, £1 3 0. 3 months, 11s. 6d.
Other Countries: Year, £2 9 0. 6 months, £1 4 6. 3 months, 12s. 3d.

No. 1640. Vol. XXXVII. MAY 30, 1940 Thursdays, Price 9d


# The Outlook

## Persons and Property

MAY 22, 1940, will go down to coming generations as equal in importance—and will have to be memorised by our descendants in schools—with the signing of Magna Charta. On that day "The Mother of Parliaments" agreed to sign away the hard-won liberty of every man, woman and child in the United Kingdom. The fact that the legislation was passed in 2 hours 43 minutes should convince even Herr Hitler that a democracy can act quickly when it makes up its mind to do so. The Government took the power to control every person and all property in the country. That does not mean that everyone will at once be taken from his present job and put to making munitions, but it does mean that if, in the opinion of the Government, a man is engaged upon work which is not helping the war effort, he can be transferred to work of national importance. Moreover, it means (in the case of aircraft work) that if any particular factory is slack for a time, possibly due to a change-over to another type of aircraft, Mr. Ernest Bevin, as Minister of Labour and National Service, can transfer workers to another factory where more workers are wanted. That he will not hesitate to do so, and that he will have the goodwill of workers, we are quite sure. He has established a Labour Supply Board under his own chairmanship, the members of which are officially described as "Directors of Labour Supply."

As to the appeal of the Minister for Aircraft Production that aircraft works should work 24-hour shifts, including week-ends, opinions in the industry appear somewhat divided, although nearly all factories have, as a matter of course, responded to the appeal. If sufficient man-power is available to work three shifts, well and good. In that case, provided the materials are forthcoming, we shall obviously obtain a very substantial increase in output. But if one or other of these two essentials is absent, the net gain, although substantial, will fall short of what is aimed at.

One must bear in mind that aircraft and aero engine production is very exacting work. An operative who works very long hours must inevitably become tired towards the end of his shift, and, as a consequence, he will produce less average work per hour, even if his output for the period is greater. That there will be a slight falling off in quality is also a possibility which cannot be altogether ignored.

The control of property will mainly, although not entirely, consist of so regulating profits that no company or individual will be allowed to make more than the ten per cent. to which it was agreed to limit aircraft manufacturing firms when the R.A.F. expansion started some years ago. Anything above that profit will revert to the Exchequer. With the justice of that decision few will quarrel. In such a time of national emergency no one ought to make excessive profits out of the country's needs.

The *Evening Standard* last week put the position in a nutshell. We have given up everything to Mr. Attlee, it said, instead of to Hitler. We can get it back from Mr. Attlee.

## The Fighting Spirit

THE world has marvelled at the work carried out by the Royal Air Force this last week. We on *Flight* have known for many years that the R.A.F. is second to none, and we have not hesitated to say so. But now proof has been given to others less familiar with its composition and organisation. One of the finest broadcasts of the war was that given last week by Air Marshal Sir Philip Joubert de la Ferté. One remark of his in particular was indicative of the way in which the R.A.F. has, to borrow a phrase used by Sir John Salmond in the last war, "its tail well up." So long as the Air Force can meet the enemy on fairly even terms, say, three enemy aircraft to one of ours, it does not mind. And it is worthy of note that this is

at least the rate at which the R.A.F. has been downing the *Luftwaffe*.

Actually, the Royal Air Force has repeatedly taken on far greater odds than three to one. So much is this the case that the Germans now hesitate to come to grips unless they are in very superior numbers. While we may admire and applaud the pluck of the R.A.F., we do feel that it is all wrong that the Service should be asked to face such odds. If the Government had shown its present initiative and drive from the very start of the war, there would not by now have been any need for the Royal Air Force to take on the huge numbers of German aircraft which it is tackling daily—and nightly. Let all of us resolve to do all we can to see that the disparity is reduced without any avoidable delay. That is the least we can do for our plucky youngsters in the air.

## "Looking Forward"

"THERE can be no doubt that when a country is fighting for its life, its primary aim is to win the fight. That is not, however, our sole aim. It is generally agreed that we are fighting, too, for our civilisation. It would seem axiomatic, then, that we must preserve the means of civilisation, of which civil aviation is one."

In this sentence, taken from the introduction of his Wilbur Wright Lecture, Dr. Roxbee Cox expresses the complete justification for the decision of the Council of the Royal Aeronautical Society to hold this year's lecture on the date decided, i.e., May 30. While the prospects of reviving civil aviation may appear very slim at the moment, the day will come when we shall want to revive it, and it will be a poor outlook for us if we have made no provision for picking up the threads.

No matter how hard we are fighting for our existence, it is foolish to take the view that we cannot spare a couple of dozen men to specialise on the planning and design of post-war commercial aircraft types. Designing offices are not as hard pressed as all that, whatever may be the state of the works, and it is very essential that something should be done to organise such a development. The Wilbur Wright Lecture, a report of which will appear in next week's issue, gives a great number of hints as to the directions in which designers should look.

## Initiative

ON the subject of future success, Dr. Roxbee Cox pleads for technical initiative. "We must," he says, "have ideas, develop them and use them. Too often we seem to have had ideas and forgotten them until others have developed them. In the histories of, for example, flaps, metal construction, and retractable undercarriages, we made a creditably early appearance, but we only used these devices when their value had been proved elsewhere." Dr. Roxbee Cox might have included the variable-pitch airscrew. The Hele Shaw-Beacham was one of the earliest in the world, but for many years the Air Ministry failed to realise its value, and development lagged behind. But for the faith in the v.p. airscrew of a few individuals, and of the Gloster company, the Hele Shaw-Beacham, now become the Rotol, might have languished and died.

**EGYPT TESTS HER DEFENCES. Massed flights took place over Cairo last week, the population being greatly impressed by Britain's air strength. Here are three Bristol Blenheims flying over the pyramids.**

# WAR in the AIR

## *Battle for Channel Ports Continues : The R.A.F. Continues to Harass the Enemy*

FOR yet another week the German drive for the Channel ports has gone on with scarcely any perceptible slackening in intensity—or is there just a slight dulling of the first keen edge? Reports of air combats talk of losses in twenties and forties. No longer do we hear claims of ninety or a hundred brought down in a single day. Second-line machines such as the Junkers Ju 86 and DO 17s begin to put in an appearance in Flanders and, although the position of the Allied forces is serious, it is by no means so bad that only reserve material need be used against them.

### A Dangerous Position

ON the face of it, the German disposition of his troops is equally critical for him, because a week of rain and low visibility could easily land their advanced mechanised units in a major disaster. Until now the weather has been dry and it can easily be seen, from photographs taken in France, that where the R.A.F. have scored direct hits on important road junctions, the enemy tanks and transport have just skirted the crater and passed on. A week of rain would involve them in a sea of mud which is always in favour of the side with the shortest communications. Low visibility would prevent the use of aircraft bombing to anything like the extent it has been used up to the present, and under such circumstances the French should not have great difficulty in closing the Bapaume-Peronne gap which is the focal point of the whole battlefield. This may sound very much like wishful thinking—if it rains it is a fact.

However, so far the Germans in their air tactics have followed their tradition of mass attack, irrespective of losses, as followed in 1914. The increased tempo of modern warfare has the difference in effect that a superiority in weight of attack achieves results more rapidly—and those results may be more decisive. For this reason it must be expected that the enemy will continue to concentrate every ounce of their air power into consolidating and enlarging their gains in Scandinavia and the Lowlands.

It is now revealed that the bombing of the German occupied aerodrome at Waalhaven was not the first war outing of the new Bristol Beaufort; it had already been used with considerable success in the Norwegian campaign. The Beaufort, it will be remembered, is a mid-wing all-metal monoplane fitted with two Bristol Taurus sleeve-valve engines. The wing span is about 58 feet and the length 44 feet. It is used for bombing, reconnaissance, torpedo-dropping, and general purpose duties. Carrying a torpedo or a bomb-load, and defensively armed with one mid-fuselage turret, the Beaufort is cast for an important part in the naval and coastal operations which may develop off the Low Countries. Although the Beaufort was designed by the Bristol Company immediately after the Blenheim, it is not a mere development of the Blenheim—which itself has been used extensively in attacks on enemy cruisers. The Beaufort is considerably faster than the Blenheim and, having been designed especially for the job, is the finest machine of its type in the world. It got its name from the Dukes of Beaufort. In attacking armed surface craft torpedo-dropping aircraft usually dive from a

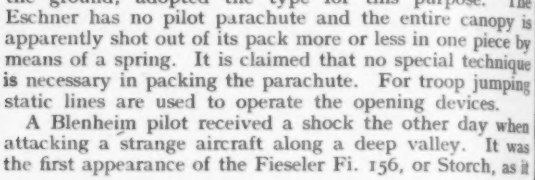
*"Flight" photograph.*

**The demonstration by Herr Seimondl of the quick-opening Eschner parachute at the opening of Luton Aerodrome in 1938. Note the torn canopy.**

**Parachute jumping practice from a Ju 52 on the ground.**

## WAR IN THE AIR (CONTINUED)

A photograph taken from the Ju. 52 showing the low height and short interval between jumps.



The German Eschner parachute. Note the absence of any pilot chute.

considerable height to within a few feet of the water, finally releasing the torpedo when close to the objective. Barrages of pom-pom and machine-gun fire from the enemy naval craft make high performance in torpedo-droppers a first essential. The Beaufort is now in quantity production for the R.A.F. at home, and is being built for the Royal Air Force in Australia.

Little did the crowd who witnessed the demonstration of the Eschner parachute at the opening of Luton aerodrome in July, 1938, realise they were watching something which would have such a far-reaching effect in the future. Herr Seimondl, who made the jumps, showed how it is possible with this quick-opening type of 'chute, to leave the aircraft when as low as 150ft.—our photograph shows him doing it. The Germans, with their aptitude for turning things to account for military purposes, realising the advantages of the short drop for parachute troops, since it is during the descent that the men are so vulnerable from the ground, adopted the type for this purpose. The Eschner has no pilot parachute and the entire canopy is apparently shot out of its pack more or less in one piece by means of a spring. It is claimed that no special technique is necessary in packing the parachute. For troop jumping static lines are used to operate the opening devices.

A Blenheim pilot received a shock the other day when attacking a strange aircraft along a deep valley. It was the first appearance of the Fieseler Fi. 156, or Storch, as it is called. The Blenheim was returning over Germany after a successful bombing attack on an enemy bridgehead when he sighted an unfamiliar type of aircraft flying low along a deep valley. Diving at more than 300 miles an hour, the Blenheim pilot attacked with his front gun, opening fire at about 35 yards. "To my amazement," the pilot reported afterwards, "the enemy aircraft appeared to stop and stand still in mid-air, forcing me to over-shoot." Pulling out of his dive the R.A.F. pilot sought to renew the attack, but the enemy aircraft was now flying so low that the steepness of the gorge prevented further attack. The mystery of this "hovering" aircraft was solved later, when the Blenheim pilot identified it from a photograph as a Fieseler "Storch," a German trainer-type aircraft which has such extensively slotted wings that it is endowed with remarkable slow-flying qualities.

Its proper name is Fieseler Fi. 156, and it is used sometimes for army co-operation work, especially for observation, for which its low speed makes it eminently suitable.

This aircraft was evolved from a number of successive types built by the German firm of Gerhard Fieseler Werke, founded by Herr Gerhard Fieseler, the acrobatic pilot who designed the earlier models especially for his aerial displays.

Although the Fieseler Fi. 156 has a top speed of something like 110 m.p.h. its stalling speed is only 31 m.p.h. A speed that is definitely "hovering" compared with normal modern speeds.

Pilots of a Battle squadron after an attack on the encroaching German forces. It will be seen that they now carry small arms.

## WAR IN THE AIR (CONTINUED)

### Air War in Brief

Modern air fighting was illustrated when one Hurricane pilot, as he fought, warned another by radio-telephone that a Me. 110 was getting on his tail.

* * *

On the night of May 19 a strong force of Hudsons paid a visit to Vaernes aerodrome, close to Trondheim. Flying in line astern they dropped "sticks" of bombs across the buildings and landing ground. Seven fires were started.

* * *

The objectives of a night raid on Sunday, May 19, included large oil storage tanks at Misburg, near Hanover, and important roads and bridges behind the enemy's lines at Gembloux, Givet, Dinant and Namour. On the way home one of the raiders reported that the oil storage tanks at Bremen, which had been bombed the previous Friday by other Whitley aircraft, were still well alight. Wellingtons and Hampdens were used for the road and bridge targets.

* * *

So effective has been the striking power of the Hurricanes that one case is reported of a German reconnaissance machine being shot into two pieces—the tail was cut completely off—by the bullets from the eight Brownings.

* * *

From Italian sources comes the report that the enemy is using towed gliders, each carrying six to eight men, for attack on special targets. Their silence and low landing speed are considered a great advantage as they can approach without noise, and can be landed almost anywhere.

* * *

A.A. gunners on the East Coast attacked a "phantom" bomber—a British Hampden flying empty, with neither pilot nor crew, on its way home from Germany. German gunners had already crippled the Hampden. The crew, except the pilot, had "baled out" over Germany. Single-handed, the pilot had nursed his aircraft across the North Sea, fighting every mile of his long journey to maintain height. As he crossed the British coast, he was picked up by a searchlight. He was "all in" and his aircraft was in no condition to make a safe landing. He said, "Well, thank God, that's England anyway," and stepped out. At that moment the A.A. gunners, receiving no recognition signals, opened fire. As the pilot floated down in his parachute he thought of the "parashooters" who might be waiting beneath. But his luck held. He landed safely on a road, and was able to establish his identity.

* * *

The German claim for Wednesday, May 22, amounted to 120 aircraft destroyed. They generously admitted that 10 of theirs were missing.

* * *

The chairman of the Allied purchasing commission in Washington disclosed that American-made bombers are being flown across the Atlantic. He declined to give any figures or discuss the route.

* * *

There was a case of eight Hurricanes tackling 35 Ju. 87 dive bombers. The Hurricanes were patrolling near Arras when they encountered the German bombers flying at 1,200ft. and about to make a bombing attack. As the Nazi raiders dived, the British pilots swooped down on their tails. Six of the bombers were definitely destroyed, while three more were so badly damaged that they were unlikely to reach their base.

* * *

Air Marshal Joubert de la Ferté in a broadcast on May 23: "Whenever the R.A.F. met the Germans in fair fight, that was to say one British aeroplane to three or four Germans, the victory had been on our side. We had been rather obsessed by Germany's industrial power and her ability to turn out an immense number of aircraft. What neither she nor any other nation could do was to go on producing trained crews at the rate at which they had been lost by her in the recent fighting. Our bomber losses had been successfully made up and although we had lost a number of fighter aircraft the losses in trained pilots had not been severe, and had also been made up. Above all, the spirit of our new pilots was the same as that of their predecessors, and they would take on the Germans on the same terms as before."

* * *

At Geldern, a German town near the Dutch frontier, four heavy bombs from a Hampden scored direct hits on an ammunition train. This immediately blew up with an explosion which rocked the aircraft thousands of feet above.

* * *

On May 24 a single patrol of Spitfires shot down eight Me. 110 two-seater fighters for certain, and probably 14 in all, in addition to three German bombers. One Spitfire of this patrol was seen to crash, and two others are missing. The remaining eight Spitfires returned safely.

* * *

One squadron of Spitfires accounted for eighteen enemy aircraft in one day. This was the same squadron which sent up eleven fighters and shot down eleven Germans in one engagement.

* * *

Another Spitfire squadron spread their successes over the day. They shot down a Henschel near Calais at breakfast-time, a Condor near Ostend before lunch, a Dornier 17 and a Junkers 88 a little later, another Dornier 17 and two more Junkers 88 at teatime, and two Messerschmitts before dinner.

* * *

When a Hurricane Squadron attacked a formation of thirty Heinkel and Dornier bombers between Calais and Dunkirk the protecting Messerschmitt 110's held off from the fight. The Hurricanes first shot down five, and probably seven, of the bombers at 11,000ft. Then they climbed to 22,000ft. and put three of the Messerschmitts out of action.

* * *

The biggest single air battle of all time took place over the Calais-Dunkirk area between the hours of 5.30 and 9.30 on the morning of Sunday, May 26. Formations of Ju. 88s, Me. 110s, Spitfires, Hurricanes and masses of Me 109s took part. An Air Ministry statement on the outcome of the fight claimed at least 20 enemy bombers and fighters shot down and an equal number put out of action. In the four hours continuous fighting there was only five British casualties.

**A Bramo Fafnir engine of a Dornier Do 17 shot down behind the French lines.**

# HERE and THERE

### American Deliveries

ACCORDING to *The New York Times*, 2,300 aeroplanes out of the 6,100 ordered since the outbreak of war have now been delivered. The paper also states that many deliveries have been made ahead of schedule, and that in no case have they fallen behind schedule.

### Aircraft Detection

ON May 27 the New York correspondent of *The Times* reported that the United States Army has perfected an aircraft detector which is so sensitive that it can pick up approaching aeroplanes at a distance of 50 miles. Officers of the Signal Corps are reported to have expressed the view that the new locator is "far in advance of any similar equipment available to belligerents abroad."

### Canada Speeds Up

MR. HOWE, Acting Minister of Supply, said in a broadcast last Thursday that there had been a universal response to his appeal for accelerated production, and that his department had been inundated with patriotic messages. The Minister for Air, Mr. Power, also broadcast. He said that all Canada's energy would be put into the Commonwealth Scheme, and that pilots would be trained first in hundreds and then in thousands. Aeroplanes and pilots requested by the R.A.F. were being sent forward immediately. There was no reservation, and there would be none.

### The Royal Aero Club

THAT many members of the Royal Aero Club are serving overseas, while others in Government Departments have gone to the provinces, has resulted in a considerable falling off in the regular use of the club. Members are therefore reminded that they can assist materially by making use of the club whenever opportunity offers. Those who cannot do so for any reason are still able to help by recommending members of H.M. Forces for Honorary Membership. There must be among our readers many members of the Royal Aero Club who have friends serving in the Forces, and who could help both their friends and the club by making use of this privilege.

### New German Equipment

AN Italian claims to have interviewed an engineer who saw the latest Messerschmitt, the Me 115, flying at Augsburg. This machine is very similar to the Me 109 and is said to be manufactured on many of the jigs and tools made for the latter.

The Me 115 gives the impression of being an Me 109 with clipped wings, its span being only about 31ft. The wings are of a different shape (so that the area is not necessarily less), and a new type of flap is used. The machine has a Daimler-Benz engine of 1,200 h.p. and appears to be very fast and, in the hands of the test pilot, fairly manœuvrable.

From the same source it is learnt that the Do 215s are soon to be fitted with Daimler-Benz DB-603 engines of 1,500/1,700 h.p. These units, it is said, are being produced on a large scale and should be in service by the end of the year. It is learnt that the 2,000 h.p. DB-605 has not been particularly successful, and that the air-cooled radials of 1,500 h.p. have not proved very satisfactory either.

Of the He 113 fighter it is said that the span is 30ft. 10in.; length 26ft. 11in., and height 8ft. 2in. The wing area is reported to have been reduced to 155.75 sq. ft. The engine is a DB-601S of 1,200/1,300 h.p., and armament comprises one shell-gun on the engine and two large-bore sychronised machine guns in the centre section.

### Bombers Over the Atlantic

ACCORDING to a report issued in Washington last week, Mr. Arthur Purvis, president of the Anglo-French Purchasing Commission, is said to have stated that a few of the larger American bombers had been flown across the Atlantic, and that others would follow as soon as they were completed. We publish the announcement without comment.

### Another U.S. Giant

NOT to be outdone by the Army Air Corps, the U.S. Navy has released some few particulars of the huge flying boat which is under construction for it at the Glenn Martin works in Baltimore and which overshadows in size the Douglas B18 bomber which was reported in these pages recently.

The gross weight is given as 84 tons, which is considerably bigger than the 70 tons of the B19. Wing span is 230 ft., and cruising speed is stated to be 200 m.p.h. Other figures which are reported are: Useful load 32 tons (which would be 38 per cent. of gross weight, a large percentage); horse-power 9,000; range 12,000 miles; and crew 15. The figure for the range is the one we are most sceptical about.

### Aircraft Commission in Australia

THE personnel of the Aircraft Production Commission, whose duty it is to supervise the manufacture and maintenance of the aircraft to be provided by Australia, is as follows: Chairman, Mr. Harold Clapp (who is also general manager of the Aircraft Construction Branch); members, Mr. F. J. Shea (chief engineer, Aircraft Construction Branch), and Mr. J. Storey (of the car manufacturing firm, General Motors-Holden Pty. Ltd.).

The duty of the Commission is to exercise full control of all schemes for the manufacture of aircraft engines, airscrews, and aircraft in the Commonwealth. It will supervise the departmental factories, examine the details of all contracts entered into, and arrange for the supply of all tools, equipment and material. Another of its duties is to develop local sources of raw and fabricated material, and it is also charged with the limitation of profits. As well as manufacture, the Commission will look after the maintenance and repair of R.A.A.F. aircraft outside the Air Force establishments.

Under the Commission's control are the manufacture of Beaufort, Tiger Moth and Wirrawy airframes, twin and single-row Pratt and Whitney Wasp engines, and Gipsy engines.

### Tyre with Outside Valve

THE Musselman Products Company, of Cleveland, U.S.A., have produced a tyre and tube in which the valve does not go through the rim but is entirely clear of it. The valve stem is of rubber and is short and flexible. It is said that punctures can be repaired without removing the tyre from the wheel and that tube damage from "creep" due to under-inflation is prevented.

### Improved Magnaflux Technique

PARTS made of bronze and duralumin are now being tested by the Magnaflux system in the workshops of Transcontinental and Western Air. Previously this method has only been applied to ferrous metals but the new technique applied by T.W.A., in which the fluid containing small iron particles is poured over the part under test, enables cracks in bronze and duralumin parts to be detected. Under the older method parts were dipped into the fluid.

### Completely Blind Flight

A FLIGHT, entirely on instruments and without sight of the ground, was made between two points in April in U.S.A., when a Boeing "flying fortress" was flown between Long Island and Langley Field, Virginia, which are about 300 miles apart. Both the take-off and the landing were made by instruments and the pilot did not see the ground between opening the throttle at Long Island and finishing the landing run at Langley Field.

### U.S. Engine Production

MR. MORGENTHAU announced last week that the American Government has acquired all engine patents from manufacturers and will lease them out to private firms. The object is to reduce the number of types and to facilitate quantity production. Mr. George Mead, who is well known in this country, has been entrusted with the task of organising engine production. He has the assistance of three members of the California Institute of Technology.

### R.A.A.F. Reorganisation

SINCE Air Chief Marshal Sir Charles Burnett arrived in Australia to take charge of the Royal Australian Air Force some changes in organisation have occurred. The "command" system of administration has been instituted and there are four such command areas. The southern command comprises Tasmania, Victoria, South Australia and the southern Riverina. Central New South Wales is known as the central command, while northern New South Wales, Queensland, Northern Territory and Papua make up the northern command. The western command consists of Western Australia.

The Air Board (which contrary to many people's ideas deals only with military aviation and has nothing to do with civil aviation) is led by Sir Charles Burnett as Chief of the Air Staff. The Member for Organisation and Equipment is Air Marshal R. Williams, while Air Commodore W. H. Anderson is Member for Personnel. The Director-General of Supply and Production is a newly-created post, filled from outside the Air Force. The fifth member, Mr. M. C. Langslow, is Finance Member.

The S.E.5.

The D.H.2.

The Sopwith Pup.

# AIR ACES of the LAST WAR

*While Admiring the Work of the R.A.F. During the Last Few Days, it is of Interest to Remember the Tactics Employed by its Predecessors*

By CAPTAIN NORMAN MACMILLAN, M.C., A.F.C.

IT is difficult to define just what an air ace is. The term has been so frightfully abused as to lose any significance it ever possessed. It was definitely not coined by the fighting pilots. The German method was more direct. A *Kanone*—the equivalent of our Ace—was a pilot who had destroyed five enemy aeroplanes in personal combat. Well, somehow (in spite of the fact that the Press has sometimes erred on the other side) the British ace of the last war, by common consent, meant something more than the German *Kanone*.

At one time or another it has been my good fortune to meet most of the outstanding fighter pilots of the last war. There were some thirty pilots all told of the R.N.A.S., R.F.C. and the R.A.F. who shot down twenty or more enemy aeroplanes: Ball, Barker, Bowman, Bishop, Campbell, Carter, Cobby, Collishaw, Compston, Dallas, Fall, Frew, Fullard, Gilmour, Hoidge, Jones, Leacroft, Little, McCudden, McElroy, McKeever, MacLanachan, McLaren, Mannock, Maxwell, Mimlie, Proctor, Quigley, Rhys-Davids, and Woollett.

Would anyone grumble if we called these pilots aces? They destroyed between 900 and 1,000 enemy aircraft. They came from all parts of the Empire, from the cities as well as the country. No better proof is needed that an ace is not the product of the place of his birth but of the stuff that is in him.

Usually the victor of many air fights possessed perfect eyesight, but Mannock was an exception, for one of his eyes was defective. And Mannock was one of the greatest (Taffy Jones calls him *the* greatest) of them all. Possession of the fighting spirit is the first essential in the making of an ace. Without it nothing can prevail, not even the greatest skill in flying, not even superiority of aircraft and equipment. With it, the fighting pilot often outfought enemy machines of superior performance and emerged the victor.

### *Patient Practice*

But none of the great air fighters of the last war rose to eminence in their work by accident. Their outstanding ability to win air fights was almost invariably the result of patient practice in shooting and in handling their aeroplane solely as a means to that end.

More than one of the pilots I have mentioned would have been poor performers at an air display. It would be invidious to mention names, but some of them crashed many good British aeroplanes through lack of skill in landing. Some of them, however, were pilots whose flying was meticulously polished. So again it is impossible to lay down any hard and fast rule that exceptional flying ability made the best fighting pilot. Sometimes it did and sometimes it didn't.

Again, some of the outstanding pilots were lone hunters, who roamed the skies like hawks ready to pounce on an unwary enemy. Others won all, or nearly all, their victories when fighting in formation. But in each case the employment of skilful tactics was a necessary forerunner of success. The formation fighters had to drill their pilots as well as lead them; every new pilot who joined the Squadron without previous experience of war flying had to be instructed in his duties and shepherded through his first few flights over the lines until he had acquired the capacity to distinguish friend from foe and the ability to fly in the relative space that a goldfish has in a bowl without crashing into any of the twelve to fifty aeroplanes that were also circling in the imaginary bowl. And every fighting formation leader always told off one of his more experienced pilots to guard the newcomer until he had found his balance.

Every famous fighting pilot had to go through that patch of helplessness on first meeting enemy machines, when he hadn't the faintest notion of what was happening around him. But some were better prepared for it than others because they had a superior quality of imagination which enabled them to visualise the difficulties and discount them to some extent in advance. Those who possessed this faculty employed it throughout their whole career, to their own manifest advantage and that of those who flew alongside them.

### *A Hard School*

Few of the fighting pilots had much flying experience before they were in their first fight. Many of them had flown fewer than thirty hours all told and, of course, less than that solo. A few of them were nearly sent home by their Commanding Officers when they first reached the Squadron because they couldn't fly properly. They learned to fly as they fought, and they learned to fight as they learned to fly. It was a hard school, and luck flew with most of the pupils who graduated high up the list.

Most of the great fighting pilots paid a tremendous amount of attention to their machines on the ground. These were flimsy things by comparison with modern all-metal aircraft, and their flying qualities depended upon careful attention to rigging; often a few more miles an hour were to be gained by a little experimental alteration in the rigging of wings or tail. Engines were nursed on the ground. They were not the powerful and reliable mechanisms of to-day. The rotary varieties had to be completely overhauled every thirty hours or so. And with engines of the low power of that time (all fighter engines never exceeded 200 h.p. and most were much less powerful) every fraction of a horse-power counted, and the efficient pilot helped his mechanics to find it.

So, too, with the guns. The famous fighter pilots saw

to their guns on the ground. They supervised their loading. They tested their alignment. They practised shooting on the ground and in the air; war provided plenty of ground targets for the latter practice.

During the last war there was considerable change in types of fighters. The earliest fighters were just small scouts with a Lewis gun mounted on the centre-section of the upper plane. Then came the D.H.2 pusher, with the pilot seated in a small nacelle in front of the wings, and his gun mounted upon an upright and capable of being swivelled independently of the machine. That period was followed by single-gun types like the Nieuport, with its Lewis gun on a Foster mounting on the centre section. This enabled the gun to be pulled down to shoot upwards. In the Sopwith Pup and Triplane there was a single Vickers gun firing through the airscrew. These gave place to the Camel, the S.E.5 and the Snipe. The S.E.5 had a Vickers gun firing through the airscrew and a Lewis gun on a Foster mounting; the Camel and Snipe carried two Vickers guns that fired through the airscrew.

### *The Two-seaters*

Two-seater fighters were the Vickers Gunbus, the F.E.2D and the Bristol Fighter. The fighting of the two-seaters came into a different category. They were usually employed on Army duties, and were often engaged on long reconnaissance work. But those machines did carry out many offensive patrols also, when fighting was the main reason for their taking the air. Nevertheless, their work was almost all formation flying, and the famous fighting pilots all aspired to fly single-seaters, and all got single-seaters eventually.

Every fighting pilot of the last war, after he emerged from the elementary stage of inexperience, began to evolve his own special tactics. As a rule, they were the result of his own experiences. But one and all had the same factors: Surprise, Power of Manœuvre, and the Effective Use of Weapons.

Different pilots went about things in a different way. Some of them (Ball and Barker were of that order) achieved surprise by the boldness of their action in going bald-headed for the enemy the instant he was sighted. Others sought to achieve surprise by the art of stalking (Bishop's method). On one occasion Bishop got within fifteen yards of a German aeroplane and shot him down without being seen, because three Germans were intent on the destruction of one British plane. Both Bishop and Barker adopted the direct attack on the enemy aerodrome to get machines as they came up off the ground. Others manœuvred with care to get the advantage of height, or to be screened by the sun. All avoided being silhouetted against cloudbanks.

### *The Advantage of Height*

At the low speeds then obtaining in aeroplanes, the advantage of superior height was great. The ability to dive not only enabled the attacker to press home his attack and prevent the escape of the pursued, it also reduced the time in which the opponent could adopt counter measures for defence, and gave the attacker superior power of manœuvre as a result of the speed gained in the dive. Often superior height enabled the attack to be made by surprise, thus helping to ensure that the attack was pressed home to victory. It enabled one machine to attack a formation. It enabled a smaller formation to attack a larger one with success.

Every famous pilot employed power of manœuvre to get into the best position to shoot, and upon occasion to escape from a dangerous situation. All paid great attention to the shooting power of enemy machines and to their effective fields of fire when they were multi-seaters. Some pilots endeavoured to get into the blind spot of two-seaters, under their tail or three-quarter front; others came down on the tail in a dive and shot the observer out of action first. The single-seater was always attacked from the rear.

At some time or other every famous pilot got himself into a tight corner. Barker's single-handed encounter with sixty German planes was the tightest of all. When that happened, a combination of power of manœuvre and use of weapons was required to escape. To attempt to run away was to court death. To fight a retreat was the one safe method to adopt, turning, twisting in a homeward direction, with every now and again a bull-dog rush at an enemy plane to upset the attack plans of their superior numbers. Even a lone pilot usually got away because the attackers employed mob tactics instead of leaving two machines to close in and so shoot straight.

The master pilots of the last war were deadly shots. I have known one to shoot down an enemy in flames with ten rounds, and to crash an enemy with only four bullets. The novice, on the other hand, would blast away hundreds of rounds with no apparent effect. Occasionally, when circumstances demanded it, the crack pilot might open fire at long range—say, two hundred yards. But as a rule the closer the range the better he liked it. For at really close range—from thirty to five yards—there was less chance of missing with the first burst of fire. And it was that first burst which was usually so deadly when experts pressed the triggers.

### *They Were Individualists*

Seldom did the pilot in the enemy cockpit know he was up against a far more practised foe until it was too late for him to do anything about it. All the records of the great fighter pilots show that, once they got into position to shoot, the enemy was as good as doomed. And just as he knew that, the expert knew also that he must never allow himself to be caught with an expert on the enemy on his tail. The art of successful air fighting was contained in the axiom that it is more blessed to give than to receive. The fighter pilot's skill was all attuned to that end. He was prepared to take risks, but had no intention of wilfully committing suicide. And in war he had the great advantage of being an individualist. A duellist rather than a soldier, he could pick his adversary, and if he were sufficiently skilful he might pick his conditions for the duel also. Having done that, whether he rode to war alone or with a consort of pilots behind him, he pressed home his attack to the uttermost with daring, with tremendous concentration of purpose, alertness of mind, complete absence of confusion of thought, and deadly accuracy of fire.

The most famous aces were born because the spirit was in them. But more than that was required. Training to fly, to shoot; knowledge to see that aircraft, engine, guns and sights were tuned always to perfection; patience to attend to the details in person; ability to conquer fear in its early stages; luck to survive the early days and so learn to recognise enemy from friend. And then steady, relentless training for air combat alone or in formation; power of leadership; inspiration; courage; belief in the cause for which the war was being fought; coolness in the tightest corners; terrific concentration for a fraction of time while the target centred in the sights and the thumbs pressed the triggers gently so that the plane did not swerve one iota from its course. Those were the qualities which the aces of the last war possessed or cultivated. And they were qualities which made other men look up to them and admire them, and in recognition of which mechanics toiled ungrudgingly night and day so that the aeroplane they tended would never let its pilot down if they could help it.

Deeds' right with Mr. Orville Wright on his left. I had no difficulty with my subject, when Colonel Deeds asked me to speak, because I had been introduced as the representative of the Royal Aeronautical Society, which had discussed the problem of flight ever since 1866, and were still discussing it when the Wrights invented and built a machine such as we had dreamed of, and then took it out and flew it. Most of those present were fellow-townsmen of those persevering inventors, and I could see a smile of pride on many of those faces as they listened to my short account of the great endeavour which had been born in their home town.

I had several opportunities of hearing the attitude arrived at by the American people towards the war. No one criticised our stand for the preservation of democracy, though many doubted the wisdom of our Government. It seemed only a matter of time when the Western World would come into the battle line, and in the meantime the obstructions to America giving material help were rapidly dissolving. The quickness with which each neutral was drawn into the Nazi net had alarmed them as nothing else could have done, for, after all, the U.S. is one of the neutral nations, and they are naturally wondering, in this fight against World Dominion, how long it will be before their own turn comes.

All Americans seemed wishful to help. Some wanted to come in right now; others were in favour of supplying munitions free; and yet others were inclined to give credit facilities only. In fact, they all had the same end in view, and differed only in the path to be taken.

While in America I put a question to American friends which had several times been put to me before in England: Was the aeroplane a wise contribution to science? We all know that it was not in England's interest that flying should come and rob her of her insularity. English statesmen recognised this, and, therefore, did nothing to encourage flying in the early days. We have to go more deeply into this question, because it goes to the very root of advancement.

When I put the question I was answered by the putting of other questions. Was it good to invent the motor car, when it could be developed into a tank? Was it wise to invent radio (which saved all those lives on the *Titanic*, and has saved thousands since), when it could, as to-day, be used to deceive millions of people by false propaganda?

Was it wise to invent the wheel? Its omission would have left people more primitive, and presumably happier, if other people's sleighs did not crush them under their skids. In fact, the harm is not in the invention, but in the misuse to which the invention is put, and cruelty can equally well be inflicted by trampling elephants or by crushing under the wheels of chariots. It's not the weapon which is to blame; it's the criminal who misuses it.

Since leaving home in April, the European picture had changed. What looked secure a month ago looked less secure later. After all, would the hazard of landing in Genoa be less than the hazard of torpedoes in the Atlantic? And, as things were livening up, I felt that a nine-day crossing on the Cunard would be safer in the long run, besides saving a week and being about £50 cheaper. So I took advantage of the option of changing my route to any of the conference lines, or to Pan-American Airways, and subsidised the Cunard White Star Company to the extent of £63 for room and bath. I felt that in doing this at the expense of the U.S. lines I was helping to win the war with the aid of our wealthy cousins. The voyage back was uneventful, although a thrill went through the vessel when a ship appeared on the horizon. I was waiting with four other guests in the captain's cabin, at his invitation to cocktails, and our host was ten minutes late. His reason for unpunctuality was that he had to wait until he could determine whether the ship was British or foreign. We drank our cocktails in mutual congratulation at the first description proving to be the correct one.

I must not name the ship on which I returned nor the date or port of arrival, but we zigzagged our way until, on the ninth day out from New York, we docked in this somewhat worried island just in time to get home before the black-out.

---

## Good, But—

*"Aerosphere, 1939," by Glenn D. Angle; 15 dollars; Aircraft Publications, 370, Lexington Avenue, New York, N.Y.*

THE value of this impressively large volume lies chiefly in Mr. Glenn D. Angle's contribution on the world's aero-engines which refers to the great majority of aircraft power plants ever built, including even the steam engine constructed in France by Clement Ader in 1890. It seems, however, that Mr. Angle has been more successful in his historical research than in garnering data relative to the most modern engines. For example, no figures are given for the Rolls-Royce Peregrine though the ratings for this unit were published in *Flight* many months ago. It is irritating, incidentally, continually to find "Kestrel" written as "Kestral."

On the other hand, the information given on the development of the Allison liquid-cooled engines and on a number of other modern units more than offsets these shortcomings.

Although the section dealing with aircraft is not intended to be historical and is, in fact, entitled *Modern Aircraft*, it nevertheless deals with such archaic machines as the Gloster Gauntlet and Fairey Hendon, though the Vultee Vanguard and a number of other recent types are not covered.

The publishers have issued some illuminating statistics on the volume. It is apparently considered important that *Aerosphere* has twice as many pages and weighs twice as much as *Jane's All the World's Aircraft*. The total number of pages is 1,420, made up as follows:— World's Aircraft Engines Section, 844; Modern Aircraft Section, 202; Statistical Section, 63; International Directory Section, 274.

It will be gathered that *Aerosphere* is not a well-balanced work. In fact it seems that Mr. Glenn Angle, after writing a very commendable review of aero engines, decided to add a catalogue of aircraft data and a directory and to offer the volume as a comprehensive review of all the world's aeronautical material. Nevertheless, *Aerosphere* is a magnificent and undeniably useful production.

## A Chance for Men Over 40

THE Anglo-French Ambulance Corps sent their first section, of 22 ambulances with women drivers, overseas for service as long ago as April 3. Now a second section, also of 22 ambulances, is being got ready and will leave England shortly. This, however, will have male drivers, as will also subsequent sections to be sent over.

Here seems to be a chance for those ex-service men and others over military age to do a real man's job on active service. Applicants must be experienced drivers, and must be between the ages of 41 and 60, and drivers must supply their own uniforms. Applications should be sent to Colonel J. Baldwin-Webb, M.P. (the Hon. Sec. of the A.F.A.C.), at 33, St. James's Street, London, S.W.1. Upon arrival in France they will be enrolled in the French army, and will serve entirely with and under the French Ministry of War, who will provide billets and rations.

## The Wilbur Wright Lecture

THE Royal Aeronautical Society announces that the 28th Wilbur Wright Lecture, delivered by Dr. H. Roxbee Cox, is to take place as arranged on May 30. The Council of the R.Ae.S. has probably acted wisely, even if, in these critical times, civil aviation is largely of academic interest.

Dr. Roxbee Cox has chosen for his title "Looking Forward," and even in present circumstances that is a very necessary thing to do. Although the author is concentrating on civil aviation, there is much in the paper which can be applied, directly or indirectly, to military aviation. The sub-title is intriguing. It reads: "Prolegomena for a Detailed Study of the Future of British Civil Aviation." Probably most of our readers will have to consult a dictionary for the meaning of "Prolegomena." *We* did.

WESTLAND LYSANDERS: These army co-operation machines have lately had an opportunity of proving their worth.

# SERVICE AVIATION

## *Royal Air Force Official Announcements*

### *The King's Message*

H.M. The King has sent the following message to the Royal Air Force:—

"During my visit to the Headquarters of the Bomber Command to-day, I was able to hear more about the epic deeds of our Bomber Forces in recent weeks. Coupled with the arduous and unceasing duties of the Coastal Command, and with the heroic exploits of our Fighter squadrons in this country and in France, they make an immortal story—a story that fills the whole Empire, whose sons are now fighting in all three branches, with gratitude and admiration.

"I congratulate the Royal Air Force with all my heart and wish them good luck, and continued success. The matchless spirit that has shown so clear an ascendancy over the enemy makes the final victory of the Allies doubly sure."

(Signed) GEORGE, R.I.

### *Awards*

IN recognition of the work of the Advanced Air Striking Force the following message has been sent to the Air Officer Commanding-in-Chief by General Georges, the Commander of the North-Eastern Group of Armies:

"I address my congratulations and thanks for the wonderful effort sustained through three days by the British Air Force in low flying and bombing attacks.

"The French Army salute the memory of the British airmen who have sacrificed their lives for the salvation of our two countries."

The King has approved twelve immediate awards to personnel of this force:

DISTINGUISHED FLYING CROSS.

Flt. Lt. W. Simpson, P/O. T. D. H. Davy, Wing Cdr. L. D. Dickens, Flt. Lt. W. Blom, P/O. W. M. Corbett.

DISTINGUISHED FLYING MEDAL.

Sgt. E. N. O'Dell, A/C.1 G. N. Patterson, Cpl. R. T. Tomlinson, Sgt. J. R. Paine, Sgt. A. N. Spear, Sgt. T. R. V. Kitto, and Cpl. D. J. Barbrooke.

One of those who received the D.F.C. was, with five other volunteers, chosen to attack two bridges which spanned the Albert Canal. He was attacked by a Messerschmitt Me109 and believed that he shot it down. His own port wing tank had been damaged, however, and the white petrol vapour led him to believe that his aircraft was on fire. He gave orders for the crew to jump and then brought the machine down within ten miles of his base.

THE KING has been graciously pleased to approve the undermentioned awards in recognition of gallantry displayed in flying operations against the enemy:—

DISTINGUISHED FLYING CROSS.

HAYES, FLYING OFFICER THOMAS NORMAN.

F/O. Hayes was pilot of one of six aircraft that attacked Rotterdam aerodrome. In company with his commanding officer he destroyed a Junkers 52 on the aerodrome by machine-gun fire. Whilst climbing, after the dive, the formation was attacked by twelve Messerschmitt 110s. F/O. Hayes was unable to see the enemy aircraft himself, but skilfully manœuvred his aircraft on instructions from the air gunner. After a short while he sighted a Junkers 52 and, although hard pressed by superior numbers of other enemy aircraft and with his own aircraft damage, F/O. Hayes attacked the Junkers 52 with tenacity and determination until it was seen to go down with its port engine on fire. Breaking off the engagement and skilfully evading his opponents, he made for home, but shortly encountered three Heinkel 111s. He courageously attacked with his remaining ammunition and succeeded in breaking up their formation before arriving safely at his base.

DISTINGUISHED FLYING MEDAL.

HOLMES, CORPORAL GEORGE HENRY.

Cpl. Holmes was the air gunner in F/O. Hayes's aircraft in this action. After the attack, the formation was engaged from astern by twelve Messerschmitt 110s. Cpl. Holmes displayed coolness and initiative in advising his pilot how best to manœuvre his aircraft to evade the enemy. Even when handicapped by petrol fumes from a tank burst by enemy action, he continued to give accurate information. His gallant conduct under intense fire was largely responsible for the pilot's being able to take evasive action and to bring the aircraft safely home.

DISTINGUISHED FLYING CROSS.

SMEDDLE, ACTING FLIGHT LIEUTENANT HUGH LOMAS.

This officer was leading a formation of three aircraft on a bombing operation against Ypenburg (Holland) aerodrome. When about two miles from the objective, a large number of Messerschmitt 110s attacked the formation and two of the three aircraft were forced to retire. Flt. Lt. Smeddle continued towards his target alone until a cannon shell burst in his cockpit, wounding him and his observer; a second shell exploding at the rear of the aircraft, wounded his air gunner and wrecked the wireless apparatus. In spite of severe wounds and the loss of his compass and wireless, Flt. Lt. Smeddle succeeded in throwing off the enemy attack and bringing his aircraft safely home to its base. By his great courage and determination he saved his aircraft and the lives of his crew.

GROUND DEFENCE: Personnel charged with the defence of R.A.F. stations against low-flying attacks practice with Lewis guns against toy balloons.

## R.A.F. Benevolent Fund

THE Twentieth Annual Report of the Royal Air Force Benevolent Fund has just been published.

Voluntary subscriptions from serving officers and airmen, at the rate of one half-day's pay per annum, brought in a sum of £11,111 which, it is expected, will continue to increase.

A total of £797 was contributed by the leading aircraft companies, including £300 from Imperial Airways, Ltd., £105 each from the Bristol Aeroplane Co., Ltd., Fairey Aviation Co., Ltd., and Rolls-Royce, Ltd. (the last named making a special donation of £100 in connection with Empire Air Day); £52 10s. from Blackburn Aircraft Co., Ltd.; and £50 each from Boulton Paul Aircraft Co., Ltd., and De Havilland Aircraft Co., Ltd., under Deed of Covenant. Blackburn Aircraft Co., Ltd., also donated £100 towards the cost of equipping the "Wakefield Wing" of Vanbrugh Castle School.

## Casualties

*Air Ministry Communiqué No.* 30.

THE Air Ministry regrets to announce the following casualties on various dates. The next of kin have been informed.

KILLED IN ACTION.—L.A/C. H. Baguley (529181); P/O. K. J. Drabble (40610); Sgt. D. G. B. Falconer (523067); Sgt. G. B. Irvine (580456); L.A/C. P. J. Lamble (550831); F/O. P. H. Rayner (90022); Sgt. T. D. Smith (580500).

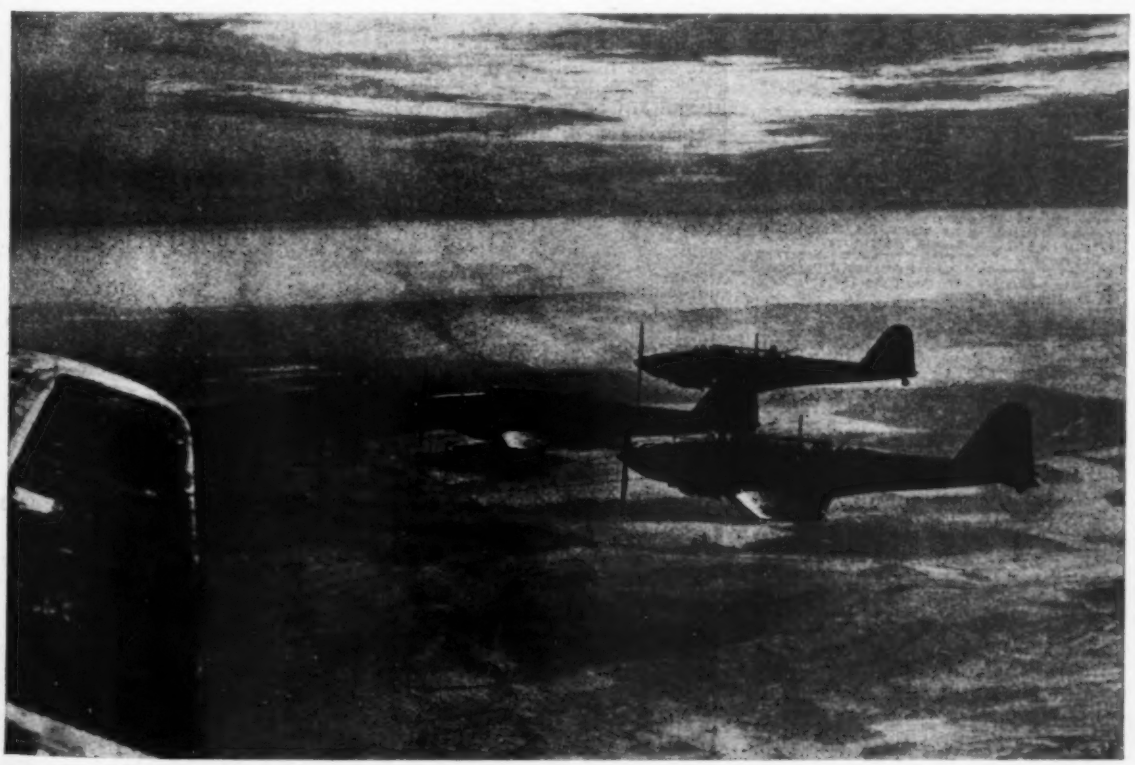
PREVIOUSLY REPORTED "MISSING," NOW REPORTED "KILLED IN ACTION."—Sgt. J. A. L. Barter (751471); Sgt. J. C. Carpenter (745604); A/C. 2nd Class G. Eveson (635904); A.Flt. Lt. P. W. H. Kite (40231); P/O. A. F. Lemaistre (41033); A/C. 1st Class G. H. Maile (543456); A/C. 1st Class R. L. Millar (569861); L.A/C. F. A. Morrison (522580); L.A/C. D. W. B. Upham (562805).

WOUNDED OR INJURED IN ACTION.—L.A/C. R. W. McCarthy (532666); P/O. A. F. M. Wilson (41767); Sgt. A. Young (563811).

MISSING, BELIEVED KILLED IN ACTION.—Sgt. W. J. Anning (525720); Sgt. D. I. Anthony (561995); L.A/C. T. H. Bowen (521480); Sgt. H. F. Bullock (565115); Cpl. G. H. Dixon (533999); Flt. Lt. A. C. Heath (37173); P/O. T. Hurst (33588); L.A/C. O. A. Hutchinson (524532); A.Flt. Lt. B. R. Kerridge (39199); Sgt. C. H. Lowne (580167); Sgt. S. A. Nicholls (746976); Sgt. C. J. S. Poole (580416); L.A/C. C. B. Wells (551357); F/O. M. C. Wells (37535).

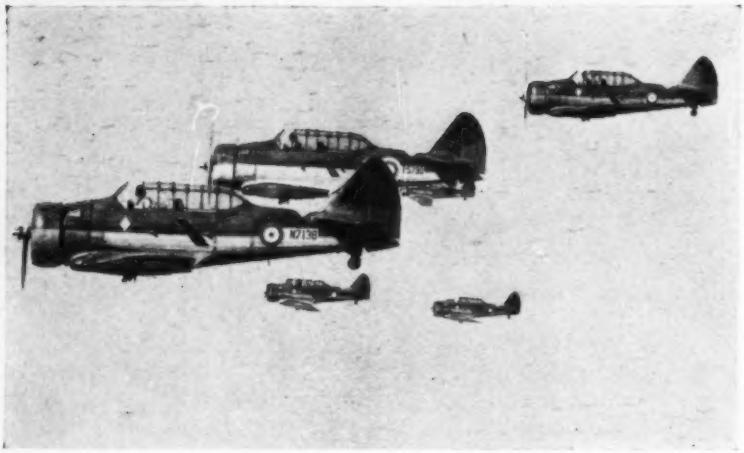
MISSING.—P/O. M. H. Anderson (90497); F/O. T. G. Bassett (40781); A/C. 2nd Class R. W. Bence (619972); P/O. A. H. Benson (43131); Sgt. J. T. Bowen (515101); Sqn. Ldr. R. L. Bradford (33019); L.A/C. H. Bridson (539332); Sgt. J. R. Brooker (564099); L.A/C. E. W. Burnett (613517); F/O. R. M. Burns (33304); P/O. J. L. G. Butterworth (40798); L.A/C. W. T. Cavanagh (542287); L.A/C. C. C. Child (541344); Sgt. J. Christie (517808); F/O. C. A. R. Crews (37795); L.A/C. R. D. Davies (539392); Sgt. T. W. Davis (580509); A/C. 2nd Class M. J. Delahunty (636904); A/C. 1st Class A. Ellis (550453); L.A/C. T. R. Evans (536059); Sgt. K. D. Footner (580423); F/O. D. E. Garland (40105); L.A/C. H. T. Garbett (533153); A/C. 1st Class B. Gill (621946); P/O. I. L. Gray (36188); Sgt. F. W. Gregory (580512); P/O. G. F. Harding (35438); Sgt. T. C. R. Harrison (580203); L.A/C. H. C. W. Hawkins (800567); P/O. A. P. B. Hordern (41418); F/O. A. J. Hudson (39125); P/O. O. P. de L. Hulton-Harrop (41585); Cpl. G. Hurford (521567); Cpl. L. D. Isaacs (800520); Sgt. C. M. Jennings (580427); Sgt. N. S. D. Jones (580417); Sgt. J. B. Keegan (580581); Sgt. B. E. S. Knowles (580790); Flt. Lt. A. W. Lee (37323); Sgt. E. E. B. Le Voi (562560); Sgt. J. A. A. Luck (524114); P/O. D. J. T. Lusk (70413); L.A/C. W. A. McFadden (545595); Sgt. R. I. L. MacKenzie (580459); F/O. A. McPherson, D.F.C. (39200); Sgt. A. A. Maderson (517089); Sgt. F. Marland (514450); P/O. A. W. Matthews (400031); A/C. 1st Class D. Meyrick (551640); Sgt. N. C. Middlemass (580461) A/C. 1st Class S. W. Mills (625774); F/O. C. R. Moore (90098); Sgt. M. Moore (565347); P/O. J. D. Morrison (41096); L.A/C.

**BATTLE DRESS: A new battle dress is being tried out in France by units of the R.A.F. A report on its suitability for general adoption will be made by the wearers.**



**BATTLE FORMATION: Fairey Battle bombers which have been harassing the enemy in company with Blenheims and Lysanders. Whitley, Wellington and Hampden bombers have also been attacking heavily from bases farther from the Front.**

## Service Aviation



TUTORIAL: North American Harvard advanced trainers (Pratt and Whitney Wasp) from an R.A.F. Training School.

J. D. Openshaw (551751); L.A/C. H. F. Over (551639); F/O. A. D. Panton, D.F.C. (33331); A.Flt. Lt. E. Parker (39111); Sgt. M. G. A. Pearce (565936); L.A/C. J. L. Perrin (537397); L.A/C. L. R. Reynolds (550860); P/O. A. C. Roberts (40140); Cpl. R. K. Rye (551184); Sgt. J. C. Sands (515799); P/O. N. A. Savill (41956); A.Sqn. Ldr. W. L. Scott (34225); L.A/C. J. C. Senior (580311); Sgt. K. N. Shrosbree (516530); F/O. G. W. Sle (40149); L.A/C. R. Sloan (517038); Sgt. V. Spurr (561257); Sgt. H. R. Sunderland (755141); Sgt. I. L. Thomas (580177); Sgt. N. H. Thompson (580843); Sqn. Ldr. G. C. Tomlinson (05214); L.A/C. R. B. H. Townsend-Coles (625503); L.A/C. P. A. Tyler (541348); L.A/C. R. H. Tyler (552475); Sgt. E. H. Ward (516975); Sgt. J. Whalley (562373); A/C. 2nd Class R. A. Wood (624992); F/O. S. P. Woollatt (39451).

KILLED ON ACTIVE SERVICE.—Sgt. V. Allison (519436); P/O. J. T. Berryman (33506); A/C. 2nd Class R. F. J. Bowie (900589); Sgt. H. I. Child (745894); Sgt. N. F. F. Giddings (564658); L.A/C. C. J. Goddard (551885); Sgt. P. R. Lutley (745415); L.A/C. V. C. E. Neirynck (645692); P/O. G. Polglase (75995); P/O. L. O. Rogers (41741); A.Sgt. E. O. F. Schmid (746761).

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. G. W. Acock (565068); P/O. E. R. M. Appleton (42475); Flt. Lt V. A. Dawson (28182); A.Sqn. Ldr. G. H. Sheenan (37587); F/O. A. H. H. Tollemache (90100).

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Sgt. L. Evans (741838).

DIED ON ACTIVE SERVICE.—Aircraftwoman 2nd Class S. U. Carpenter (8808891; Cpl. J. E. Hall (334167); Cpl. L. F. Hayes (523892); A/C. 1st Class K. Howdle (628638); Sgt. I. J. McKay (5278361; A/C. 2nd Class F. E. C. Purvis (807265); A/C. 1st Class A. Quincey (651827); A/C. 1st Class F. G. Settle (624835); A/C. 2nd Class N. F. Southgate (900660).

PREVIOUSLY REPORTED "MISSING," NOW REPORTED "PRISONER OF WAR."—Sgt. V. H. Barr (740019); A/C. 1st Class F. Hargreaves (619153).

PREVIOUSLY REPORTED "MISSING, BELIEVED KILLED IN ACTION," NOW REPORTED "PRISONER OF WAR."—F/O. M. W. Donaldson (37389); P/O. F. D. Middleton (40735).

*Air Ministry Communiqué No.* 31.

KILLED IN ACTION.—F/O. W. S. C. Adams (27100); A/C. 2nd Class O. R. Beaumont (552443); A/C. 1st Class R. Charleton (628854); P/O. R. W. H. Echlin (77117); F/O. N. Johnson (39533); A/C. 1st Class J. G. Pickard (539009); L.A/C. J. Rooney (544996); Flt. Lt. G. F. A. Skelton (29147); P/O. E. A. Vagg (70825); P/O. H. G. Webb (43154); Sgt. D. Wolstenholme (530446).

PREVIOUSLY REPORTED "MISSING," NOW REPORTED KILLED IN ACTION."—Sgt. N. Haithwaite (524167); Sgt. J. F. Hayes (580893); F/O. O. G. Horrigan (39525); A/C. 2nd Class C. C. Whitley (632190).

WOUNDED OR INJURED IN ACTION.—Sgt. H. J. Barron (580276); A/C. 1st Class A. E. Cave (615262); L.A/C. T. D. Clegg (524429); P/O. W. H. Corbet (41152); P/O. H. J. R. Dunn (33411); A/C. 1st Class A. H. Dupe (559099); F/O. T. B. Fitzgerald (40783); A./Sqn. Ldr. D. C. P. Good (39459); P/O. D. T. Jay (42063); A.Flt. Lt. R. H. A. Lee, D.F.C. (33208); L.A/C. L. H. Lightfoot (551530); P/O. R. A. Marchand (42070); P/O. D. V. G. Mawhood (40314); A/C. 1st Class A. W. Newton (536600); Sgt. K. Railton (581030); F/O. J. H. C. Rowe (90089); Flt. Lt. C. D. S. Smith, D.F.C. (33287); P/O. W. G. Spencer (41960); A/C. 2nd Class J. Traynor (638470); L.A/C. E. S. C. Williams (527375); Flt. Lt. G. M. Wyatt, D.F.C. (37337).

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—A/C. 1st Class A. Hepburn (620438).

MISSING, BELIEVED KILLED IN ACTION.—Sgt. T. R. Barker (580937); L.A/C. A. C. B. Burgess (544110); P/O. R. T. L. Buttery (70894); P/O. I. Campbell-Irons (40603); Sgt. L. C. Flisher (564186); L.A/C. R. H. Hinder (551612); A/C. 2nd Class W. C. Waterson (630224); A.Flt. Lt. A. D. Watson (39249); Sgt. A. L. F. Webb (564469).

MISSING.—L.A/C. F. J. Allam, D.F.M. (540542); P/O L. J. Ashfield (40198); Sgt. G. Atkinson (5805557); Sgt. T. T. Atchinson (580497); P/O. D. M. Barbour (33505); Wing Cdr. E. C. Barlow (15181); L.A/C. V. St. G. Barrow (542271); P/O. F. S. Bazalgette (70790); Sgt. F. E. Beames (522176); Sgt. G. Beardwood (526936); Sgt. G. C. Bennett (580299); F/O. D. Blew (39705); P/O. J. Boon (40597); Sgt. D. J. Bowen (581262); F/O. D. A. Cameron (39455); F/O. J. A. Campbell (39492); Sgt. G. A. Cartwright (580604); P/O. C. J. E. Chamberlain (40508); P/O. G. E. Chandler (35559); Sgt. F. Checkley (580605); Sgt. E. Clarke (580485); Cpl. T. F. S. Clark (535562); A/C. 2nd Class L. R. Clarke (617362); Cpl. A. C. Collyer (539279); Sgt. G. F. Couzens (565544); P/O. C. D. Crawley (41380); A/C. 2nd Class W. E. M. Davies (627554); F/O. R. H. de Montmorency (33185); Sgt. C. J. E. Dockrill (563473); A.Flt. Lt. M. S. Donne (33186); Sgt. P. F. Dormer (563966); F/O. P. N. Douglass (39933); A/C. 2nd Class W. Draper (617133); P/O. G. K. R. Drimmie (33472); Flt. Sgt. W. A. Dunn (563086); F/O. W. H. Edwards, D.F.C. (40045); Sgt. F. J. J. Evans (561705); Sgt. J. Fancy (52485); Sgt. T. Fortune (521800); F/O. L. Fredman (90405); L.A/C. J. H. K. Gegg (551672); F/O. C. F. Gibson (39981); P/O. R. G. M. Gilmore (40382); F/O. G. R. Grattan (39728); Sgt. P. C. Gray (580511); Sgt. T. Gray (563627); Sgt. R. Greenhalgh (515182); P/O. P. E. J. Greenhous (42000); A/C. 1st Class K. G. Gregory (551303); F/O. G. E. Grey-Smith (39460); Sgt. A. W. H. Hadley (580490); Sgt. H. R. Hall (564340); A/C 1st Class F. Hands (616584); A/C. 2nd Class E. Hannah (970492); Sgt. W. H. Harris (560630); Sgt. C. S. Hart (580370); L.A/C. H. Hatton (551631); F/O. P. A. Hawks (25078); Sgt. S. D. Hibberd (564714); P/O. A. M. Imrie (40711); L.A/C. H. B. Jones (536398); A/C. 2nd Class T. Jones (624943); A/C. 1st Class L. F. Jordan (624246); Cpl. B. A. Kidd (800235); Sgt. R. A. P. Kirby (518693); A/C. 1st Class L. M. Langton (615807); P/O. F. S. Laws (41431); Flt. Lt. C. M. Lester (37109); Cpl. H. F. Little (530918); Sgt. R. Lowe (581231); A.Wing Cdr A. N. Luxmoore (28112); L.A/C. P. J. McDonnell (538044); A.Sgt. F. W. McKinlay (581187); L.A/C. D. L. McLeish (581467); P/O. C. C. D. Mackworth (40728); A.Flt. Lt. A. J. Madge (39098); A/C. 1st Class E. W. Maltby (621178); A/C. 1st Class S. Martin (550964); Cpl. J. W. Maxey (506611); A/C. 2nd Class J. R. Mayor (643912); Sgt. K. Mellership (580586); L.A/C. A. E. Millard (615087); Sgt. R. F. Miller (521994); Sgt. A. C. Morgan (563340); Sgt. V. H. Moseley (580085); P/O. E. R. Mullins (41865); P/O. A. W. Mungovan (41449); P/O. H. M. Murray (41051); P/O. D. G. O'Brien (40419); L.A/C. W. E. Palmer (551629); F/O. T. H. Parrott (39112); A/C. 1st Class W. L. Parsons (612745); Sgt. T. Patterson (565191); Sgt. T. R. A. D. Pearce (564385); Sgt. E. R. Perrin (581058); L.A/C. T. Poad (551624); P/O. A. F. Posselt (41319); A/C. 1st Class J. Potter (610963); A.Cpl. F. Preston (551160); P/O. F. H. Ridley (41203); Sgt. A. J. Robertson (590388); Sgt. F. Robson (564766); P/O. V. D. M. Roe (42530); Sgt. W. G. Ross (516232); F/O. M. H. Roth (39175); F/O. P. J. H. Rowan (36133); Sgt. A. F. Sedgwick (523566); Sgt. G. E. Seldon (563402); A/C. 1st Class C. G. Shaw (6235831; Sgt. W. O. Shortland (562875); A/C. 1st Class R. Shuttleworth (626487); P/O. B. I. M. Skidmore (40644); Sgt. M. D. Smalley (580626); Sgt. W. Southward (565970); L.A/C. W. W. Street (539338); Sgt. P. Stubbs (580468); L.A/C. A. J. Taylor (540413); A.Sgt. C. Taylor (530913); P/O. A. Thomas (41352); Sgt. P. L. Thomas (563934); A/C. 1st Class J. S. Thompson (613420); P/O. S. G. Thornton (41497); Sgt. K. N. V. Townsend (566584); A/C. 2nd Class N. V. Vano (630788); Sgt. H. B. Wallis (580532); F/O. R. N. Wall (37839); A/C. 1st Class J. G. Ward (542939); Cpl. R. H. Waters (534506); A/C. 2nd Class J. A. Webster (625670); A.Sqd. Ldr. J. M. Wells (90081); P/O. H. E. White (40787); Sgt. E. J. M. Whittle (563211); A/C. 1st Class A. G. Wilson (538054); Sgt. H. R. W. Winkler (564597); F/O. G. O. M. Wright (402791).

KILLED ON ACTIVE SERVICE.—L.A/C. E. O. Backshall (751665); Sgt. O. Beck (524300); F/O. J. R. Brown (39370); P/O. R. J. Carter (78271); Sgt. R. H. Clarton (564591); P/O. W. M. A. Davies (74669); F/O. R. H. Dingle (39307); A/C. 1st Class J. Foster (552135); L.A/C. R. C. Jobling (524001); A/C. 1st Class W. K. Lambert (538419); A.Sgt. J. M. Longley (581463); A.P/O. G. J. McFarland (42413); F/O. A. C. J. Percy (900251; A/C. 2nd Class A. N. Pulfrey (742203); P/O. K. A. Ramsay (40430); Sgt. N. F. Smith (562869); P/O. W. F. Smith (41958); Sgt. W. H. Whitfield (740692).

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. H. C. Adams (741254); Flt. Sgt. F. T. Avent (361650); P/O. B. J. R. Brady (90403); A.P/O. V. V. L. Clarke (77688); Sgt. D. B. Crabtree (740434); Sgt. J. Davis (590709); A/C. 2nd Class F. Eccles (640885); A/C. 1st Class A. F. Holdsworth (617613); L.A/C. A. L. W. Holt (526203); P/O. T. de T. MacDonald (32571); F/O. F. P. J. McGevor, D.F.M. (70424); Sgt. S. C. Williams (565050).

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Sgt. H. J. Barnwell (566573); A/C. 2nd Class C. A. Wadman (630909); A/C. 1st Class F. Wallwork (743867).

DIED ON ACTIVE SERVICE.—A/C. 2nd Class L. Austin-Duck (977072); A/C. 2nd Class F. J. Foster (913626); A/C. 2nd Class G. B. Hodgson (981980); Flt. Sgt. R. E. Pope (349414); L.A/C. R. S. Wass (510142).



ADVANCED FIGHTER STATION: A Hurricane goes off to look for trouble over the Front.

# COMMERCIAL AVIATION

## *Pooling Air Transport : A Suggestion*

JUST after the capture of Holland, a friend of ours in one of the British air transport companies said to us: "How it would help the Allies to pool the air transport of France, Britain, Belgium and Holland!"

And no doubt it would. Here we have four countries, each with its air transport activities seriously handicapped. K.L.M is cut off from its own country and has lost some of its aircraft. Sabena is in a somewhat similar position, while France and Britain are endeavouring to keep some civil aviation going despite the requisitioning of aircraft and the complications inseparable from a state of war or "non-belligerency" over half of Europe, with the imminent prospect of the half becoming the whole.

A service to Lisbon is an obvious necessity, and K.L.M. were operating and British Overseas Airways planning one before the invasion of Holland robbed the Dutch airline of both maintenance base and aircraft. There is no need for both companies to run to Lisbon—if the Dutch do it they will go from England in any case—and it would be far more efficient for only one to be engaged on this work.

The French are the obvious ones to look after the Atlantic, south and north if possible, as Britain is unable to do anything there. There remain the other two major routes, to South Africa, and to the East and Australia. Both ourselves and the Dutch are operating on the latter, and a close linking of our services should help us both. Whether this should take the form of allotting one company to a route, or specific section of a route, or whether it should consist in making available on a mutual basis all aircraft on all routes, or whether it should be only the reciprocal exchange of maintenance facilities would be for the companies themselves to determine.

But some such mutual aid seems highly desirable and would once again demonstrate that "brotherhood of the air" of whose reality, intangible though it is, we have had numerous examples in the past. The democracies must stand together, not only in arms, but in air transport, so that we may the better combat the forces of totalitarianism to which we are so diametrically opposed. Many of us in the past have ignored, or even scoffed at, proposals for the internationalisation of commercial aviation as being the "dreams of idealists." Maybe they were—so was the abolition of slavery in America the dream of an idealist, and just one solitary idealist at first, too. If ever the world stood in need of imaginative idealism coupled to reality, surely it is now, when barbarism overlooks us with beetling brows.

We cannot afford to dismiss lightly any idea which will contribute to the binding of the democracies closer together. Whether commercial aviation be finally internationalised or not, a pooling of the air transport of the democracies would be a good experiment, for we may be forced to a federated Europe after this war. If we do not achieve it for ethical reasons, we may still have to forge such an organisation for reasons of self-preservation. If we do, then air transport within its boundaries will probably be one unit under single control, and the amalgamation will be made easier by just such a step as is proposed here in regard to Air France, Sabena, British Overseas Airways and K.L.M. In any case, the pooling of the resources of four such powerful operating companies would be a most beneficial move in this time of stress, and would help to facilitate starting civil aviation after the war.

---

### *12 "Cub" Coupés for C.A.A.*

COMPLETION of 12 new Cub Coupés for the Civil Aeronautics Authority was announced recently by the Piper Aircraft Corporation. With this delivery a total of 21 Coupés have been placed in service by members of the C.A.A. since August, 1939. The first group of nine was ordered for inspectors of the private flying section. The twelve recently delivered go to the air safety and inspection sections.

### *Another Empire Boat*

*CLEOPATRA*, the new flying-boat just completed by Short Brothers for the British Overseas Airways' Empire route, is now on its inaugural flight to India. Of the S33 type, it is only the second of this class to be delivered since the war, the first being *Clifton*.

One of the passengers on *Cleopatra's* first flight was Sir Wilfrid Greene, the Master of the Rolls. He flew to Rome to renew his contacts with the Italian Government as chairman of the British delegation to the Anglo-Italian Joint Standing Committee. The flying-boat is commanded by Captain C. E. Madge, who joined Imperial Airways in 1936.

### *Air Transport in America*

EASTERN AIR LINES is now operating 23 flights daily between New York and Washington, so that "every hour on the hour" has now become an actual fact for twelve hours out of the twenty-four.

T.W.A. announce the addition of another California to New York schedule, known as "The Thunderbird." Flying through all the night hours, the continent is crossed in a little over 15 hours on the eastbound flight and 16 hours on the westbound. Four intermediate stops are made. A little slower than the "Sky Chief," fastest of T.W.A.'s schedules, "The Thunderbird" makes connection with "The Grand Canyon," operating out of San Francisco. Air transport is growing up. It seems to be a somewhat sophisticated adolescent, rather conscious of its dignity, with its "Thunderbirds," "Sky Chiefs," "Mexico Flyers" and "Silver Sleepers."

### *The Price of "Jane's"*

IN *Flight* of April 18, it was erroneously stated that *Jane's "All the World's Aircraft"* is priced at two guineas. The price of the current volume is £2 12s. 6d.

### *Aeronautical Decoration*

THE Lilienthal Society for Aeronautical Research in Germany recently awarded three Lilienthal Memorial Medals. Kurt Tank, for his engineering work on the Focke-Wulf Condor, was the first so decorated, and Dr. Heinrich Klein was also given one for his work on aircraft armament with the Rheinmetall-Borsig company. Dr. Friedrich Seewald was given the third for scientific work.

### *Scottish Services Suspended*

ALL air services in Scotland have been suspended. This action on the part of the Air Ministry came suddenly last week. Intimation was made to Scottish Airways at Renfrew that all services were to cease immediately. When word came through, several aircraft were on their way to various destinations, but were allowed to complete the round trip.

This action follows just a few days after the resumption of full pre-war services and the inauguration of the Stornoway route. While no explanation is forthcoming from the Air Ministry, it would seem that their action is just part of the general preparedness of our home defence plans.

### *Air Mail Services*

THE Postmaster-General announces that air mail correspondence can now be accepted for Cyprus. The air postage rate is 1s. 3d. per half-ounce (postcards 7d.) and the latest times of posting at the Head Post Office, King Edward Street, London, E.C.1, are noon on Tuesdays, Wednesdays, Thursdays, Fridays and Saturdays. The correspondence will be forwarded by the Empire air services to Egypt and thence by a once weekly air service, or by steamer, whichever offers the earlier arrival.

Air mail correspondence for Nigeria is now despatched twice instead of once a week, the latest times of posting at the Head Post Office, King Edward Street, London, E.C.1, being 7.30 a.m. on Tuesdays and noon on Fridays respectively.

Supplement to FLIGHT

THE AIRCRAFT ENGINEER

No. 172. (Volume XIX No. 5) 15th Year May 30, 1943

# THE TWO-STROKE AERO ENGINE

## *Some Considerations of Its Advantages and Drawbacks : How Direct Petrol Injection Helps*

By DR. ING. P. F. MARTINUZZI

PETROL injection is now a practical proposition, and the time has come to consider the problem of the two-stroke aero engine. In the past, two-stroke meant compression ignition. In that field the two-stroke engine is pre-eminent, but the future of the C.I. aero engine, particularly for war purposes, is doubtful and distant. A petrol two-stroke aero engine is difficult to imagine without petrol injection; the fuel consumption would be too high, owing to loss of fresh mixture through the exhaust. Petrol injection, which allows scavenging to be effected with pure air, places the petrol engine on the same footing as the C.I. engine.

The main argument in favour of the two-stroke engine is that, all things being equal, it should give twice the power of the corresponding four-stroke engine. The snag is that all things are not equal. The maximum m.e.p. and piston speed in the best possible two-stroke cylinder are certainly lower than in the best four-stroke; the power absorbed by scavenging reduces the net available output. The two-stroke is generally supposed to be bulkier, and the petrol consumption is always higher. All the same, there is so ample a margin in favour of the two-stroke that the question is well worth examining, the more so as much development work on two-strokes is being done in many countries; the appearance of two-stroke engines in practical aviation use is perhaps nearer than most people think.

### *Power and Size*

The two-stroke is particularly interesting at the present time, as it allows more power to be obtained from cylinders of a manageable size. The 2,000-3,000 h.p. engine is urgently needed. To obtain that power with a reasonable number of four-stroke cylinders, the bore would have to be much larger than the present standard maximum of about 6in. There is, of course, no reason why a larger cylinder, of perhaps 8in. bore, should not be successfully developed; the limit in cylinder size is certainly not yet reached. Conditions in a large cylinder are very different, however, mainly due to the changed surface/volume ratio. The development period would be long and expensive; adapting the 6in. bore cylinder to the two-stroke cycle appears easier. A 6in. bore, 12-cylinder two-stroke engine, about the size of the Rolls-Royce Merlin and of the Hispano, would give 1,800 h.p. at 2,500 r.p.m., with a b.m.e.p. of only about 130lb./sq. in.

The question of the b.m.e.p. obtainable in a two-stroke engine is crucial and deserves closer consideration. The two-stroke cycle differs from the four-stroke only in the way the exhaust and intake are effected; compression and expansion remain the same, giving similar conditions, and the m.e.p. should also be unchanged. In practice, several causes concur in making the maximum m.e.p. slightly lower in a two-stroke; but there is no difficulty in making a two-stroke petrol engine give 160/180lb./sq. in. b.e.m.p.

Unfortunately, an engine must get rid of waste heat; that is the limiting factor. Trouble would soon develop in a two-stroke engine running continuously at 180lb. b.m.e.p. To obtain a reliable engine, the waste heat, and consequently the power and m.e.p., must be reduced. This can be done because the two-stroke engine gives the same power as a corresponding four-stroke with only half the b.m.e.p., so that there is an ample margin. The question of the maximum b.m.e.p. that can be expected under service conditions will be examined later. For the moment it must be noted that the relatively low m.e.p. of the two-stroke aero engine is not a disadvantage; on the contrary. A low m.e.p. implies low mechanical stresses and a lower supercharge ratio. This means that the full rated power of a two-stroke engine can be obtained with a fuel of relatively low octane number. This is a most important point, particularly in wartime, considering the cost and scarcity of very high octane fuel. Besides, as the normal m.e.p. must be kept low, there is a wide margin for a temporary power increase for the take-off; wider than in a four-stroke engine.

### *General Layout*

Before going into technical details, the question of the most likely general layout of the two-stroke aircraft engine must be examined. The opposite-piston type (Junkers) is not suitable for petrol engines; the heat stresses on the exhaust piston are too high. Even in C.I. engines, notoriously very cool, special precautions must be taken to make the piston last. Tests made years ago by an Italian firm on a petrol engine of this type proved conclusively that the pistons cannot stand the heat.

In any case, the opposed-piston engine, though superficially attractive, is not really good. The heaviest part of any engine is the crankshaft, and the opposed-piston type has more crankshaft per h.p. than any other engine; the gears connecting the crankshafts are a further bad point. Even for automotive and stationary C.I. use, where weight does not matter much and where the inherent balance of the opposed piston engine is a real advantage, this type has had no real success. It may, perhaps, survive in the C.I. field because the Junkers people have more actual experience of two-stroke aero engines than anybody else. The U-type cylinder has the same disadvantages as the opposed-piston type.

The most likely aircraft two-stroke engine will have uniflow scavenge, with the inlet near B.D.C. and exhaust in the head. This type can have either ordinary poppet exhaust valves or a sleeve valve. As will be seen, separate scavenge and supercharge ports with asymmetrical timing will almost certainly be used in aero engines. The single

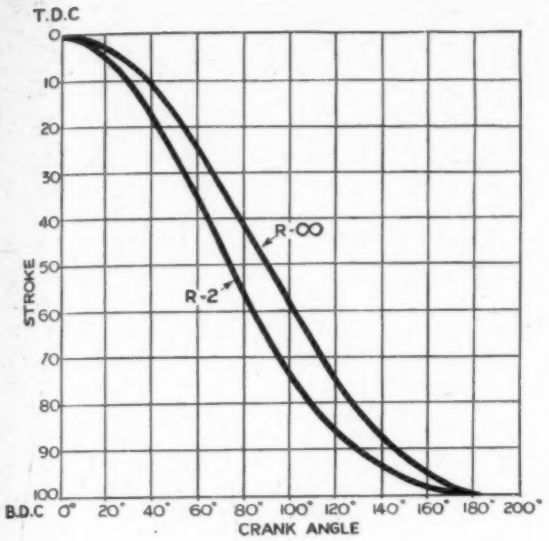



FIG. 1

**Relationship between connecting rod length and piston motion.**

sleeve gives an attractive solution to this problem, and can also be used to shorten the piston a little. It is quite likely that firms with sleeve-valve experience will use it in the two-stroke field. But others will prefer poppet valves. The single sleeve hinders piston cooling, the main problem in two-stroke petrol engines, and does not allow the piston to be shortened enough. The sleeve must run twice as fast as in a four-stroke engine, and during development work it would be difficult to apportion rightly the blame for any mishap between two-stroke cycle and sleeve valve. It is probable that the first practical two-stroke aero engines will be liquid cooled. There is no reason why an efficient air-cooled cylinder should not be developed, but liquid cooling certainly simplifies piston and valve cooling problems. Besides, air cooling means radial engines. Now, though the radial owes its success to the centrifugal blower, it is actually most difficult to fit a radial with a really efficient supercharger. But a very efficient, and somewhat large, supercharger is vital in a two-stroke aero engine. The two-stroke engine will therefore very probably be a liquid-cooled V type.

## *The Inverted Vee*

For balance and even firing, a 12-cylinder two-stroke must have a V angle of 30 deg., 90 deg., or 150 deg.; 30 deg. is too narrow, 90 deg. a little too wide. An inverted 150 deg. engine would be an elegant solution of the flat engine problem. The cyclical regularity of the two-stroke is so great, however, that smooth running can be obtained also with V angles differing from the optimum theoretical value; in practice a 12 can run well with a V angle of 45 deg. or 75 deg. A particularly attractive layout for a two-stroke is the 16-cylinder, with an optimum V angle of 67 deg. 30 min. Provided the reduction gear is located in the middle (an excellent arrangement for any V engine) there should be no difficulty in the design of such an engine, which should give well over 2,000 h.p. In the following considerations, the two-stroke engine will be assumed to have liquid-cooled cylinders, of about 6in. bore, with uniflow scavenging and poppet exhaust valves.

It has often been contended that, as it is impossible to get rid of the waste heat generated in a four-stroke cylinder under maximum output conditions, there is no reason for going over to the two-stroke cycle for aircraft engines. This argument, which implies a strict proportionality between power output and heat stresses, and which neglects mechanical stresses, is not sound. The limiting factor for the output obtainable from a reliable engine is not the total amount of waste heat; trouble is only caused by overheating of a few highly-stressed parts. So long as the known weak points stand the heat, the rest does not matter much. The waste heat of an engine, i.e., the heat not converted into work, can be divided in two parts: one is finally eliminated through the exhaust, the other is absorbed by the cooling medium, the lubricating oil, etc.

It is obvious that the heat which actually escapes through the exhaust cannot do any harm to the engine components; it is the other part that does the damage. If a two-stroke and a four-stroke cylinder have the same dimensions, etc., and are assumed to have the same thermal efficiency, the total amount of waste heat per cycle will be the same; the two-stroke, however, will give more heat to the exhaust and less to the cooling liquid than the four-stroke.

## *Short Exhaust Period*

The reason is easy to see; in the four-stroke the hot exhaust remains in contact with the cylinder surfaces for a whole stroke after the end of expansion, while in the two-stroke the exhaust period is finished 55 deg. after B.D.C.; and even before that the cool incoming air partially screens the cylinder surfaces. The rapidity of the exhaust process in the two-stroke cuts off most of the noxious transfer of waste heat from the exhaust gas to the walls.

Let us now examine the influence of two-stroke operation on the main engine components. It has already been seen that, even under equal conditions, the heat transferred to the cylinder head and liner during each cycle is less in the case of a two-stroke; this means that the total amount of heat transmitted per second is less than twice as much in the case of the two-stroke. In practice, the lower m.e.p. and piston speed of the two-stroke will reduce the heat transferred to liner and head to 150 per cent. of that of the four-stroke, while for the same reason both maximum and mean mechanical stresses are lower in the two-stroke. Head and liner should give no trouble in a liquid-cooled engine.

The exhaust valves, which might appear a delicate point, are in fact quite safe from overheating. Given two similar cylinders, the amount of gas to be exhausted per cycle is

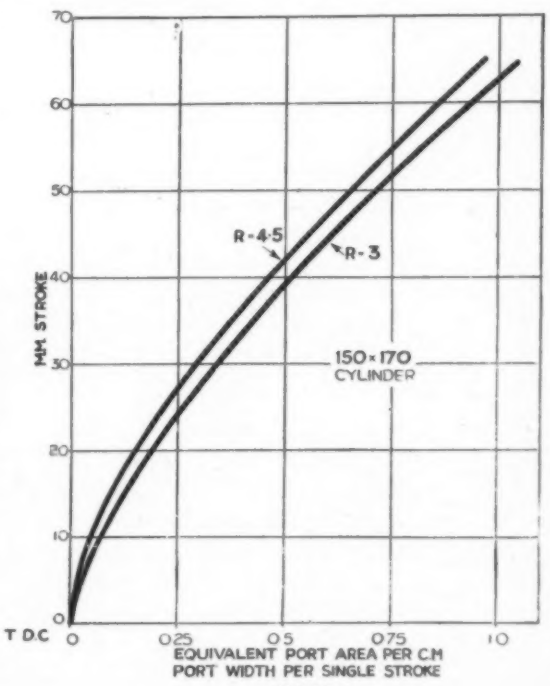



FIG. 2

**Connecting rod length and useful port area.**

the same in a two-stroke as in a four-stroke; but the two-stroke has twice the number of valves, and they remain open only half the time, thus absorbing only half the heat. Besides, though the exhaust gas is slightly hotter, the large volume of excess salvage air escaping through the exhaust lowers the average temperature considerably; even at equal m.e.p. and piston speed the two-stroke valves would be cooler.

On the other hand, the mechanical stresses, especially on springs and valve gear, are very high, owing to the limited time available for opening, and the consequent brutal accelerations. Fortunately, racing car practice gives abundant data on really fast valve operation; as silence is not required, there will be no real difficulty. Masking the valves can be useful to increase the real opening time. Anyhow, the two-stroke aero engine will probably run slower than the four-stroke; 14 m/s (2,750 feet/min.) would be quite satisfactory.

In a two-stroke engine, the piston has two distinct functions: the crown and rings withstand the working pressure and get rid of excess heat; the skirt acts as an inlet distributor. The piston is undoubtedly the weakest point of the two-stroke petrol engine, the success of which depends on a satisfactory solution of the piston problem. Considering again the two similar cylinders, the amount of heat communicated to the piston crown during expansion is the same for both two and four-stroke type. Most of the heat leaves the piston via the top rings and lands; as in the two-stroke cycle the two idle strokes fall out, and the time available to cool the piston is halved.

On the other hand, the four-stroke piston receives more heat during the exhaust stroke, while in a two-stroke with uniflow scavenge the incoming fresh air isolates the piston from the hot exhaust gas, even before the end of the expansion stroke, and helps actively to cool the piston. With petrol injection, the latent heat of the fuel can also be used to cool the piston. Even so, the piston temperature is bound to be higher in a two-stroke, and everything must be done to reduce it; m.e.p. and piston speed must be decreased, and a high expansion ratio must be used, i.e. a high compression ratio and a low degree of supercharge, thus also improving fuel consumption.

Good design can also help. The piston top must be quite flat, to present the minimum surface to the flame. Luckily in a two-stroke the valves open while the piston is near bottom stroke. In a flat four-valve head, such as is generally used in liquid-cooled engines, the red-hot valve heads face directly the piston crown and irradiate on it a considerable amount of heat; a steep pent-roof head would probably be better. Finally, the piston can be cooled by spraying the ribbed inner surface with oil; this method, used in the General Motors' two-stroke C.I. engine, subtracts heat directly from the hottest point, the centre of the crown, and so considerably relieves the top rings and lands.

### *Piston Temperature*

The piston temperature question is serious, but must not be exaggerated. Experiments by Baker have proved that the maximum temperature of a four-stroke piston increased from 220 deg. to 262 deg. C. when the power output was doubled by raising the r.p.m. from 2,000 to 4,000. If the doubled output had been obtained at 2,000 r.p.m. by going over to the two-stroke cycle, the piston temperature increase would certainly have been smaller, both for the reasons given above and because doubling the piston speed causes a considerable increase in piston friction and heat.

Piston length and connecting-rod length are vital factors affecting two-stroke distribution. The connecting-rod length, or rather its ratio to the crank radius, governs the law of motion and therefore the time available for scavenging. Fig. 1 shows piston displacement in relation to crank angle for an infinite rod ($R = \infty$) and for a very short rod ($R = 2$, too short in practice). The infinite rod gives pure sine law piston motion, the top and bottom halves of the stroke being symmetrical. The short rod causes the piston to move faster during the top half of the stroke and slower during the bottom half, during which scavenging is effected; the time available is therefore increased.

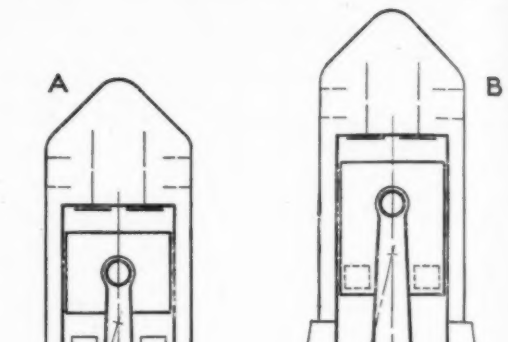



FIG. 3.

**Influence of piston and connecting-rod lengths on engine size. The normal two-stroke piston and rod are shown in B.**

Ordinary two-stroke engines, having very long pistons, must also have long connecting rods, usually $R = 4.5/5$. With short pistons $R = 3$ can be used without excessive side thrust. Fig. 2 shows the time integrals, that is, the effective port areas, for a 170 mm. stroke piston with $R = 3$ and $R = 4.5$ respectively. It will be seen that the short rod gives an average 10 per cent. increase in port area, and consequently in piston speed and power, within the usual scavenging angles. The exhaust is also similarly helped. In ordinary two-stroke engines the piston skirt is longer than the stroke, as the scavenge ports must be closed even with the piston right up to avoid loss of air. Actually, a second scraper ring is generally placed below the ports to prevent too much oil reaching them and being blown into the cylinder during scavenge.

Piston, connecting rod and cylinder liner must therefore be very long, and the overall dimensions of a two-stroke engine far exceed those of a four-stroke of the same bore and stroke. The consequent increase in weight and cross-section make this type of two-stroke engine practically useless for aircraft. The two-stroke aero engine must have a short piston and must not be any larger. A short piston can be used in a two-stroke, provided the scavenge air is controlled by a distributor to prevent air blowing into the crankcase while the piston is near T.D.C. Unfortunately, the usual type of distributor cannot prevent the uncovered inlet ports being filled with lubricating oil. The problem is not easy but it can certainly be solved; the ingenuity of designers will undoubtedly find several ways of overcoming this difficulty.

Fig. 3 shows the influence of piston and rod length on engine size. Of the two sketches, which are to scale, A shows a 150 × 170 cylinder with short piston and rod ($R = 3$). B shows one with normal two-stroke piston and rod ($R = 4.5$), the design being in each case the most compact possible. It can be seen that lengthening the piston starts a vicious circle, the increased dimensions of one part causing an increase in another. Thus, although the cylinder liner in A reaches much lower than in B, the connecting

rod clearance is actually greater in A than in B, while the longer rod in B needs a wider cross-section owing to increased column load. The dimensions of sketch A, which can be attained in practice, compare favourably with the best present-day four-stroke engines. Sketch B would obviously be useless for aircraft, though the low stroke/bore ratio actually permits a more compact design than in usual two-stroke engines (150 × 170 against 150 × 160 of the Junkers).

In a four-stroke engine, inertia forces act on the piston in alternating directions; in a two-stroke, explosion pressure causes the piston to be always pressed downwards. Consequently, large clearances can be used in the bearings without danger of hammering, and the crankshaft and big-end loads are better distributed. On the other hand, lubricating the small end and gudgeon pin is more difficult, due to the steady load. Since, however, only the bottom half of the small end and the top half of the piston bosses are under pressure, the areas in contact can be nearly doubled by suitable design alterations, and support can be given directly to the centre of the piston crown.

Scavenging and supercharging raise interesting problems. The two-stroke aero engine differs in this respect both from the four-stroke aircraft type and from the ordinary two-stroke engine. Even if an asymmetrical distribution diagram is used, the exhaust closes at the same time as the scavenge ports. As the exhaust closes at a greater rate, however, part of the scavenge pressure is recuperated. Tests have shown that, under ground conditions, the pressure in the cylinder at the close of exhaust is about that of the scavenge pump. This is true also at altitude if the ratio between scavenge pressure and the pressure of the surrounding air is constant.

If, however, the absolute value of the scavenge pressure is kept constant by means of a supercharger, the pressure difference between scavenge air and exhaust increases rapidly with altitude. This has three unfortunate consequences: the loss of air through the exhaust increases, turbulence is increased and only part of the scavenge pressure is recuperated. This loss of pressure, and therefore of charge weight, causes the engine power to fall even though the supercharge pressure remains constant. The excessive loss through the exhaust causes a loss of power through the supercharger; excessive turbulence causes the exhaust to mix with the incoming air, so that, notwithstanding the increased loss through the exhaust, the temperature and impurity of the charge are increased. The power spent on scavenging and on compressing the excess air is, of course, a net loss, and must be subtracted from the gross engine power unless a turbo-blower is fitted. In a two-stroke engine an exhaust turbine can, in practice, be used only above 10,000ft. to prevent excessive exhaust back-pressure.

The turbulence question must also be examined; the requirements of the two-stroke engine in this respect are contradictory. For good scavenging the cylinder ought to have a very long stroke, and the air should be let in with as low a pressure and turbulence as possible in order to prevent its mixing with the burnt gas. The incoming air should act like a fluid piston. In an aircraft engine, however, the stroke must be short for reasons of weight; even in the Junkers engine the stroke: bore ratio has been decreased in recent models.

On the other hand, good turbulence is necessary, both to prevent detonation and to ensure good mixing and volatilisation of the fuel in the short time available between injection and ignition. In the ordinary two-stroke the problem is complicated by the fact that, even if a satisfactory compromise is reached, a change in altitude will alter conditions, as already seen. The outlook for the ordinary two-stroke is not good, particularly for military aircraft, which must fly high. The Junkers company has succeeded in improving scavenging in their engines, which use only 30 per cent. excess air at ground conditions. This can hardly be possible in a short-stroke engine. With petrol fuel, piston cooling will demand at least 40 per cent. excess air.

Fig. 4A shows the power absorbed by scavenging and supercharging for a 36-litre engine, assuming a constant blower efficiency of 70 per cent.; that is, a variable ratio

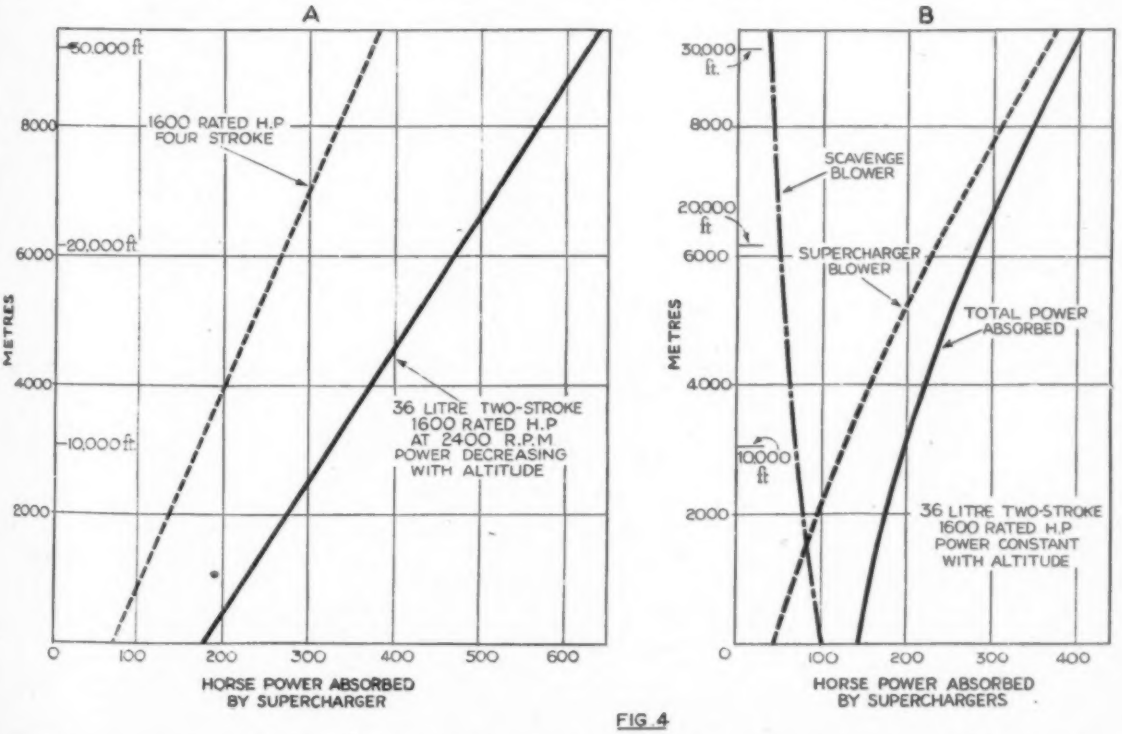



FIG 4

**Supercharger power in relation to altitude. Comparative curves for a four-stroke engine, and ordinary two-stroke, and a two-stroke with separate scavenging and supercharging, all of 1,600 b.h.p. rated power.**

in the supercharger drive. The engine would presumably give a rated power of 1,600 h.p. at 2,400 r.p.m. It will be seen that the blower absorbs about 20 per cent. of the rated power at 10,000ft. and 40 per cent. at 30,000ft. On the other hand, the rated power decreases with altitude, owing to the decrease in charge weight, as already seen. The same Fig. 4A shows also the power absorbed in supercharging a 1,600 rated h.p. four-stroke engine (with 3 lb./sq. in. boost), which is roughly half that of the two-stroke. This must therefore have a larger blower and, which is worse, an inter-cooler twice as large.

The situation changes completely if scavenging and supercharging are separated in the two-stroke aircraft engine. That is, if scavenging is effected at low pressure and turbulence while the exhaust is open, and supercharging is effected at higher pressure and turbulence after the exhaust has closed (the supercharging ports can, of course, begin to open while the exhaust valves are not yet quite closed). In this case turbulence conditions are right both for scavenging and for combustion, and do not alter with altitude. The supercharge pressure is recuperated and, if it is kept constant, the weight of charge and power do not vary with altitude. The excess air ratio also remains unaltered, provided the scavenging air is given a constant pressure rise above the surrounding atmosphere. This can be done very simply by giving the scavenge blower a fixed gear ratio. A blower of this type works at constant inlet volume and remains, therefore, always in the high-efficiency region of its curve. At least 75 per cent. can be expected. The axial compressor, with efficiencies above 85 per cent., would be well suited to this constant-volume work.

### *Power Saved*

The weight of air at (or above) ground pressure to be provided by the supercharging compressor increases with altitude. The power spent in compressing the charge up to ground conditions cannot, of course, be saved, but the power wasted in needlessly compressing the excess air is saved in this type of two-stroke engine. The supercharging ports must be kept open even when the piston has risen well above bottom dead centre. It must be noted in this connection, however, that in a naturally aspirated four-stroke engine at 20,00ft. the pressure in the cylinder is below ground atmospheric, even when the piston is well above half-stroke. Incidentally, the separation between scavenging and supercharging allows a high boost to be used during take-off.

In Fig. 4B is shown the power spent in scavenging and supercharging a 36-litre two-stroke engine with separate scavenge. The scavenge blower, driven at constant ratio, is assumed to have 75 per cent. efficiency. The supercharging blower, driven at variable ratio and giving constant absolute pressure, is assumed to have 70 per cent. efficiency. It will be seen that the power absorbed by scavenging decreases with altitude, due to the decreasing specific weight of the air, while the power spent on supercharging increases rapidly as both pressure and weight of air needed to complete the charge rise with altitude. The total power spent on scavenging and supercharging is practically the same as that of the four-stroke of Fig. 4A and only half that of the ordinary two-stroke. The inter-cooler is actually smaller than that of the four-stroke as the scavenge air does not need cooling owing to the low compression ratio. There is the added advantage that the scavenge air becomes colder with altitude, thus improving cooling conditions.

The gross engine power output increases with altitude, as the outside pressure decreases while the pressure at the end of exhaust remains constant. The best division between supercharging and scavenging differs from that assumed in calculating the curves of Fig. 4B, the results being even more favourable. It can be safely stated that the two-stroke engine with separate scavenging and supercharging is better adapted to altitude work than the four-stroke engine. The superchargers, though slightly larger than in a four-stroke, are no more complicated than the two-stage blower required by any engine flying above 20,000ft.; the inter-cooler is much smaller, a saving of over 30 per cent. being possible.

### *Sleeve-valve Control*

The distribution and inlet arrangements are certainly more complicated than in a normal two-stroke engine. It must be noted, however, that both scavenge and supercharge air are at low pressure and temperature, while a distributor is needed in any case to shorten the piston. A single-sleeve valve can provide the desired control and separation of scavenge and supercharge air; but a well-designed distributor can give even better results, with a shorter and cooler piston.

No mention need be made here about petrol injection and safety fuels; all interesting results that are not secret are being published. It must only be noted that, in a two-stroke engine with separate supercharging ports, it may be possible to place the injector in the ports and not in the cylinder; this would allow a slightly longer time for vaporisation. What has been said about the two-stroke petrol engine applies, of course, with even greater force to the aircraft C.I. engine where, owing to the high thermal efficiency, piston cooling problems are easy to solve.

It is impossible to foresee exactly the best b.m.e.p. that will be obtained in a reliable two-stroke petrol engine. As in all aero engine development, peak results become average performance in a couple of years. 115-120 lb./sq. in. at rated power and 2,500-2,750 ft./min. piston speed can be expected to begin with. During take-off the b.m.e.p. can certainly be increased very considerably. With a few years' experience better figures should be reached. Petrol consumption will probably be 5 to 10 per cent. higher than that of the best four-stroke engines. On the other hand, as the two-stroke need not be any larger or heavier than a four-stroke of the same capacity, the weight per h.p. should be much better than in the best present-day engine. The same applies to compactness. These qualities seem to indicate the two-stroke engine as particularly suitable for fighters, also owing to its fitness for altitude work. The good take-off power should be useful for flying boats.

The time is ripe for the appearance of the practical two-stroke aero engine. If the first types tested under service conditions are well designed, the two-stroke will soon find its place in the aircraft engine field. Clever design and ingenuity will be needed, however. They are catalysts or vitamins without which no amount of laboratory or bench work can hope to overcome the tremendous start that years of practical experience have given to the four-stroke engine.

## RATIONALISATION

DURING the last week or so the Government has taken steps to speed up production of armaments of all kinds. In addition to the Light Alloys Committee, of which Mr. F. S. Spriggs is chairman (announced in last week's issue) the Ministry of Aircraft Production has appointed emergency committees to deal with airframe production and with the supply of alloy steels used in the aircraft and aero engine industry.

The chairman of the Airframe Production Emergency Committee is Mr. F. S. Spriggs, of the Hawker-Siddeley group, and members of the committee are Mr. C. R. Fairey, chairman of the Fairey Aviation Co., Ltd., and Mr. A. Dunbar, managing director of Vickers-Armstrongs. Chairman of the Alloy Steels Emergency Committee is Mr. A. Matthews (Firth-Brown), and the members of this committee are: Mr. A. B. Winder (English Steel Corporation), Mr. G. Steel (S. Fox and Sons), Mr. L. Chapman (Wm. Jessop), Mr. S. G. Newton (Brown Bayleys), Mr. F. C. Harrison (Hadfields), Mr. H. Williams (Park Gate), and Major E. W. Senior (Ministry of Supply). The committee has full authority to deal with all questions relating to supply and disposition of these steels.

It is also announced that Lord Austin has retired from the chairmanship of the Shadow Aero Engine Committee, a position which he has filled with distinction since the committee was formed. Lord Austin is succeeded by Mr. W. E. Rootes.

# TURBO SUPERCHARGERS

## *Some Notes on Their Design and Construction*

By F. UMPLEBY

(*Continued from page 391c, April 25, 1940*)

REFERRING once more to the port period and timing lines Prior to the instant when the increase in air pressure manifests itself in the exhaust pipe, the cylinders and combustion chambers have been scavenged and the scavenging action persists until the exhaust port closes. At the same time, so long as the inlet port is open, the full supercharger air pressure is acting on the induction side and supercharging the engine. Here it is interesting to note, where both a four-stroke and a two-stroke engine run at the same speed, three cylinders of the two-stroke are exhausted, scavenged, and supercharged in less time than is taken for one cylinder of the four-stroke. It will also be noted that the ballistic velocity turbine is cooled by two airstreams, one from the induction side of the engine as in the Büchi, and one drawn over the rim of the wheel by the exhauster blades. The Büchi method would not be suitable for a petrol engine, unless it were operated on the fuel injection spark ignition system, or on the "pure air/rich mixture sandwich" system.

Turning once again to the turbines shown in Figs. 3 and 6, it will be seen that either a single or a multi-stage compressor may be used, and driven directly by means of a shaft carried in roller and ball bearings. The centrifugal multi-stage air compressor shown in Fig. 9 is designed with the streamline air flow laws we have discussed in connection with turbine design as its basis. The effect of this is illustrated in Fig. 8, where it is shown at A and B how the air becomes turbulent behind the blades of the conventional types of compressor, and how this trouble is avoided is indicated in Fig. 8c. When turbulence occurs the air is heated, and its density, together with the adiabatic efficiency of the compressor, decreases.

### *Two-stage Compressors*

The complete two-stage centrifugal compressor is based upon quite elementary principles. A propeller is located in the compressor air inlet, and its object is to start the air moving towards the blades of the first stage with a rotary swirl in such a manner that the air enters the blade passages with a minimum of shock. The air is compressed in the first stage and ejected into the fixed vanes between the first and second stage. Here its velocity is decreased and its pressure increased and its path of flow is changed so that it enters the passages between the blades of the second stage with the least loss.

In the second stage it is further compressed, and the kinetic energy with which it finally leaves the periphery of the impellor is converted to pressure energy by the diffuser vanes and twin volute casing prior to its leaving the compressor outlets on its way to the induction side of the engine.

The pitch of the propeller blades could be arranged so as to suit any desired altitude, but could also be automatically or mechanically varied. The ring of fixed blades between the first and second stages, being solid with the outer casing, which may be air or liquid cooled, reduces the temperature of the air as it flows through the passages between the blades, thus again increasing the adiabatic efficiency of the compressor. A two-stage compressor of this type with a single impellor is able to maintain the engine power output to a higher altitude than a single stage compressor of similar design, but such a compressor designed for high altitude would overcharge the engine at sea-level.

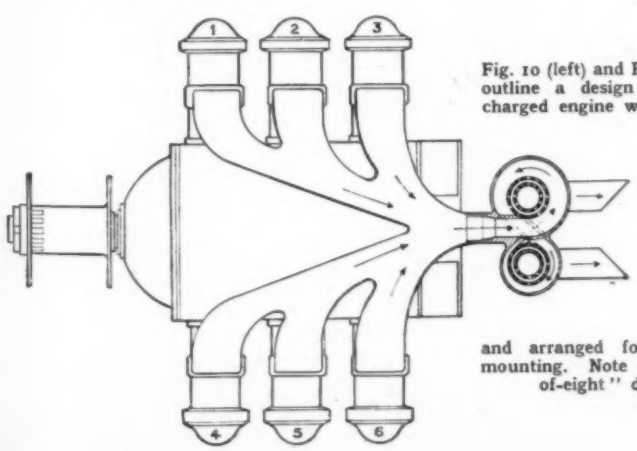
### *The Automatic Valve*

In order to counteract this, the automatic increase in speed of the turbo-supercharger as altitude increases must be supplemented by yet another control, and the conventional method of control developed for the conventional type of turbo-supercharger consists of an automatic valve to by-pass the exhaust gas from the inlet side to the lower pressure side of the turbine.* This method of control is not, however, suitable for the ballistic velocity type since its use would destroy the depression created in the exhaust system by the high velocity exit of the exhaust.

A simple form of exhaust control for this type of supercharger has been designed and patented by the writer, and is shown in Fig. 7 connected between the turbine and the two centre cylinders, but more or other cylinders could be so controlled. A valve which may be mechanically or automatically operated is used to divert the whole or part of the exhaust to the figure-of-eight device shown in Fig. 10 in more detail.

In Figs. 10 and 11, a simple two-stroke compression ignition end-to-end scavenge engine, without valves and

* "Maintaining Constant Pressure before the Carburettors of Aero-engines Regardless of Altitudes," by Leslie V. Spenser, *Flight*, Aug. 14, 1919.



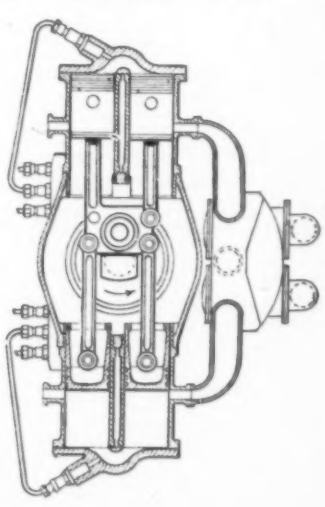



**Fig. 10 (left) and Fig. 11 (right) outline a design of unsupercharged engine without valves and arranged for horizontal mounting. Note the "figure-of-eight" device.**

arranged for horizontal mounting, is outlined. Here it will be noted that the exhaust gases are directed into the figure-of-eight which really comprises a passage of gradually decreasing cross-sectional area terminating in a nozzle which directs a curtain of high velocity exhaust gas across the entrance to the passage. This is in the same direction of flow as the main gas stream. The two limbs of the figure-of-eight encircle the two pipes by which the gases finally escape into the atmosphere. Gases entering the passage at ballistic velocity have a tendency, due to centrifugal force, to follow the outer walls of the passage and thus maintain the high velocity jet of exhaust gas which issues from the nozzle. At the same time, however, exhaust gas is discharged to atmosphere by way of the holes leading into the twin final exhaust pipes.

### *Unidirectional Flow*

The pressure and velocity of the gases in the gradually decreasing passage ebb and flow as the respective cylinders exhaust, but the gas flow is always unidirectional, and any return surges of atmospheric pressure must first overcome the resistance of the nest of holes and cells around the exhaust pipes before they blend into the unidirectional gas stream. Their ability to destroy the depression in any one cylinder is further resisted by the curtain of gas emerging from the nozzles, which is maintained to the last, independently of the length of the exhaust pipes or the speed of the engine.

During this time the depression is extending through the combustion chamber and cylinder to the induction side of the engine, and a new charge of air, or combustible mixture, is flowing into the cylinder and may even reach the exhaust port and pipes, as is indicated by the pressure curves and port timing period lines in Fig. 5.

Furthermore, these remarks apply to a considerable extent to four-stroke engines, and the severe temperature stresses in the exhaust valves and combustion chamber may be considerably reduced, and the volumetric efficiency of the engine increased, by use of the figure-of-eight arrangement. In the control of the supercharged engine, the figure-of-eight acts in combination with the turbo-exhauster section of the turbine at low altitude. As the altitude increases the figure-of-eight is gradually cut out and the turbo-exhauster takes full control, in both two- and four-cycle engines.

A further method of altitude control is available by varying the pitch of the propeller blades on the compressor, and this may be the most useful since it is below exhaust gas temperatures. By these methods I have attempted to provide a solution to the problem of the simple, powerful and reliable aero engine able to operate at high or moderate altitude. Such an engine could operate on volatile liquid fuel, either by fuel injection with spark ignition, or on the "pure-air rich mixture sandwich" system, or on high-flashpoint fuels by compression ignition.

Consider Figs. 6 and 7 as an aero engine for high-altitude work. It comprises six common combustion-chamber cylinders, without valves, in two opposed rams of three, with a total capacity of 4.2 litres.

The sleeve-valve engine owes its advantage chiefly to the absence of hot exhaust-valve heads, but this engine is free of all valves and all hot spots. Also, the rim of the turbine is effectively air-cooled, and everything makes for a cool-running, reliable power plant. Under these favourable

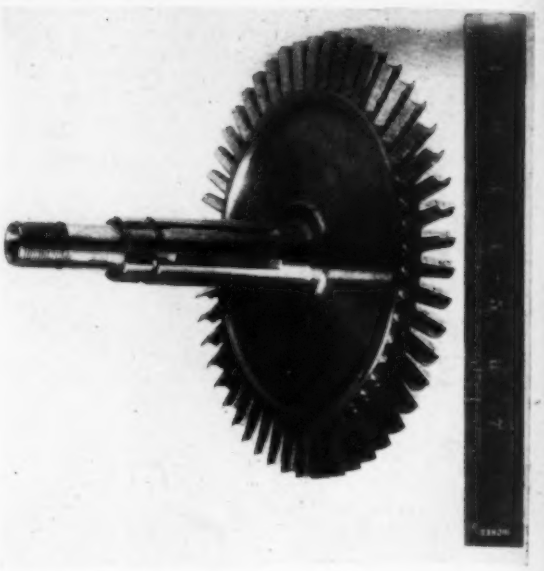


**Fig. 12. A conventional type of turbo-supercharger turbine. This particular example was made from the solid in Hadfield's "Era" heat-resisting steel.**

circumstances a power output of 336 b.h.p. at 3,700 r.p.m., with 2½ lb./sq. in. of supercharge, may be expected, that is, 80 b.h.p. per litre. This is equivalent to 4.7 b.h.p. per sq. in. of piston. These results almost equal results obtained by the N.A.C.A.† during their tests of a two-stroke engine, operating on the fuel-injection, spark-ignition system, using hydrogenated safety fuel. At a scavenge-supercharge pressure of 1 lb./sq. in., a B.M.E.P. of 130 lb./sq. in. was attained. At a pressure of 2½ lb./sq. in., 150 lb./sq. in. was attained, and the above results at 335 b.h.p. call for a B.M.E.P. of 140 lb./sq. in., and up to 9 lb./sq. in. supercharge pressure is available to give it (see Fig. 9).

As a compression-ignition engine its speed would be limited, by the operative speed of the fuel pump, to about 2,500 r.p.m., and the power output would be about 240 b.h.p. under the above scavenge-supercharge conditions. This would equal 57 b.h.p. per litre, with a B.M.E.P. of 128, and 3.37 b.h.p. per sq. in. of piston area. The more thoroughly a compression-ignition engine is scavenged, the smoother it runs and the higher the B.M.E.P. attainable.

The simple unsupercharged engine shown in Figs. 10 and 11 would be scavenged, but less power is to be expected. Here the power would be of the order of 185 b.h.p. at 2,500 r.p.m. (102 B.M.E.P., equal to 44 b.h.p. per litre, and 2.6 b.h.p. per sq. in. of piston). It is the ideal engine for light planes and commercial air transport.

I feel that it is only by working along these or similar lines that the powerful, light, and safe compression-ignition engine will eventuate.

† "Description and Test Results of a Spark Ignition and Compression Ignition, Two-Stroke Cycle Engine," by J. A. Spanogle and E. G. Whitney. N.A.C.A. Report No. 495.

## APPEAL TO AIRCRAFT WORKERS

THE Minister for Aircraft Production, Lord Beaverbrook, made the following appeal last week to all aircraft factory workers:

"All employees of aircraft factories, aero engine works, factories making component parts for aeroplanes and plants engaged on sub-contracts for the air programme, are invited to work on Saturday and Sunday, May 26 and 26, and also on Saturday and Sunday, June 1 and 2. They are asked to work by night and by day, full overtime for the present. Any firm unable to follow this advice for any reason should send me a telegram, explaining the difficulties, and I will do what I can to smooth them out."

From reports which reach us it appears that the vast majority of factories responded magnificently to Lord Beaverbrook's appeal. As an example we may quote the factories under the control of Lord Nuffield. These will work seven days a week, and where material is available overtime will be worked by both day shifts and night shifts.

It is worth noting the proviso "where material is available." That is the all-important thing.